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A Comparison of Traditional and Geophysical Strategies for Assessing the National Register Status of Archaeological Sites at Fort Riley, Kansas

Michael L. Hargrave

Federal law and Army regulation require Army installations to identify historic properties, including archaeological sites, and to determine which properties are eligible for the National Register of Historic Places (NRHP). Traditional strategies for assessing the NRHP status of archaeological sites based on hand excavation are expensive and unreliable. An alternative strategy is based on the use of geophysical survey techniques and highly targeted ground-truthing excavations. This report compares the cost and reliability of the traditional and geophysical strategies. The comparison is based on the use of both strategies at four sites located at Fort Riley, Kansas. Recommendations are made as to how geophysics can be used to reduce the costs and improve the reliability of NRHP assessments.

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Federal law and Army regulation require Army installations to identify historic properties, including archaeological sites, and to determine which properties are eligible for the National Register of Historic Places (NRHP). Traditional strategies for assessing the NRHP status of archaeological sites based on hand excavation are expensive and unreliable. An alternative strategy is based on the use of geophysical survey techniques and highly targeted ground-truthing excavations. This report compares the cost and reliability of the traditional and geophysical strategies. The comparison is based on the use of both strategies at four sites located at Fort Riley, Kansas. Recommendations are made as to how geophysics can be used to reduce the costs and improve the reliability of NRHP assessments.

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A Comparison of Traditional and Geophysical Strategies for Assessing the National Register Status of Archaeological Sites at Fort Riley, Kansas

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FOREWORD

This study was conducted for the Directorate of Environment and Safety, Fort Riley, under Military Interdepartmental Purchase Request (MIPR) No. DES5262AMP, "Recovery and Evaluation of Data from Archaeological Sites." The technical monitor for this work was Dr. Richard Shields, AFZN-ES-C.

The work was performed by the Planning and Mission Impact Division (LL-P) of the Land Management Laboratory (LL), U. S. Army Construction Engineering Research Laboratories (CERL). Dr. Harold E. Balbach is Chief, CECER-LL-P and Dr. John T. Bandy is Operations Chief, CECER-LL.

Dr. Michael J. O'Connor is Director of CERL.

MANAGEMENT SUMMARY

The 12 million acres of land managed by the U. S. Army includes thousands of recorded archaeological sites. The legal requirement to protect (i. e., avoid) these sites until their eligibility for the National Register of Historic Places (NRHP) has been determined reduces the realism that can be achieved in military training. Given the level of funding available for managing cultural resources, it will before many years before all of the known sites that warrant a NRHP eligibility assessment can be investigated.

Traditional approaches to archaeological site assessment vary from state to state, but are generally based on the hand excavation of a very small portion of each site. As a result of small sample size, traditional site assessments can be highly unreliable. Given the labor-intensive nature of archaeological fieldwork, lab analysis, and report preparation, as well as the requirement for long term curation of excavated materials, traditional site assessments also tend to be expensive. On balance, there is clearly a pressing need to develop methods and strategies that can reduce the costs and improve the reliability of NRHP eligibility site assessments.

In 1994, the U. S. Army Construction Engineering Research Laboratories (USACERL) initiated a research program to evaluate the potential contributions of geophysics to archaeological site assessment. Geophysics includes a suite of noninvasive techniques (e.g., resistivity, magnetometry, and ground penetrating radar) that can identify the location and, to varying degrees, the size, shape, and depth characteristics of subsurface phenomena. By placing hand excavated test units at those loci most likely to yield intact cultural deposits, it may be possible to reduce the total amount of excavation needed to assess a site's eligibility for the NRHP.

The study reported here was designed to compare the costs and benefits of the traditional site assessment strategy with those of an alternative strategy based on geophysical survey and targeted ground truthing. The study was conducted at four sites located at Ft. Riley, Kansas. Two of the sites (14RY3193 and 14GE3108) were primarily historic occupations, whereas the other two (14RY3183 and14RY5155) were prehistoric. More limited geophysical investigations were also conducted at a fifth site (14RY193, a historic farmstead).

Work at the four primary sites proceeded as follows: First, an archaeological contractor established a grid and prepared plan maps for each site. A geophysical contractor then conducted resistivity and magnetic surveys. The archaeological contractor then returned to Ft. Riley to conduct traditional NRHP assessments. Upon conclusion of the traditional investigations, the archaeologists excavated additional shovel tests to investigate a number of locations selected by the geophysicist. Both contractors were requested to keep detailed records of the time devoted to various activities. In this study, person hours have been translated into dollars.

The geophysical strategy was found to be quite competitive with the traditional approach in terms of cost; (the costs per site of the geophysical assessments were 50 to 60% those of the traditional assessments). In most situations, however, it would be desirable to increase the amount

of ground truthing excavations, and this would reduce the differences in cost of the two strategies.

The reliability of a site assessment strategy was defined as the success with which it detected cultural features where such features were present. If, for example, one strategy identified 10 features whereas the other strategy only identified 5 features, the former would be viewed as more reliable. In this study, it was found that the traditional assessment strategy was more reliable at one site (14RY3183), whereas the geophysical approach was more reliable at a second site (14RY3193). At a third site (14GE3108), the traditional approach was technically more reliable, but the geophysical approach clearly could have been equally or more reliable had additional ground truthing been conducted. At the fourth site (14RY5155), neither strategy identified any intact features and differences in reliability could not be assessed.

The results of the Ft. Riley study underscore the importance of using the site assessment strategy that is most appropriate to a specific site. Geophysics appears to be less useful at sites where historic architectural remains are visible on the surface, or at sites that have been extensively disturbed. Geophysics can play an important role in assessing sites where architectural remains are likely to be present but are not visible on the surface. Similarly, geophysics appears to be very effective at large sites (only a minute fraction of which could be investigated using hand excavation). Additionally, it may be effective to use geophysical surveys as an intermediate stage between site reconnaissance and site assessment. Geophysics could, for example, be used to screen a group of sites, differentiating those that warrant formal site assessments from those at which no additional work may be needed.

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ACKNOWLEGEMENTS

I would first like to acknowledge the contributions to this project made by Dr. Richard Shields, Ft. Riley Cultural Resources Manager, and Mr. John Dendy, Archaeologist, Dynamac Corporation-Ft. Riley. From the start, they have been staunch proponents of the effort to integrate geophysical techniques into archaeological site assessment on U. S. Army installations. Dick and John provided substantial technical input into this project, as well as logistical assistance to the USACERL, PSAP, and Geoscan investigators.

I am very grateful for the contributions to this project made by the late Dr. John Reynolds, Mr. Barry Williams, Mr. Martin Stein, Ms. Virginia Wulfuhle, and the rest of the staff of the Kansas State Historical Society for information they provided on the history and nature of archaeology in Kansas, and on the previous use of geophysical techniques in Kansas. We also thank Dr. Tim Weston and Chris Schoen, Kansas Department of Transportation, who provided reports and unpublished information about previous archaeological investigations in Kansas.

I would also like to thank the instructors of the 1995 course on "Remote Sensing/Geophysical Techniques for Cultural Resource Management". Coordinated by Mr. Steven De Vore, the National Park Service offers this class each year and I recommend it highly as a fine hands-on introduction to archaeological geophysics. Many of the instructors provided valuable insights in response to my questions about the time and cost issues in geophysical surveying. My conversations with Dr. Lewis Somers (Geoscan Research), Dr. Bruce Bevan (Geosight), Dr. Rinita Dalan (SIUE), Mr. Steven De Vore (NPS), and Dr. John Weymouth (University of Nebraska) were particularly beneficial. Dr. Bevan also generously provided information from his database on previous geophysical studies, as well as an unpublished report on his seismic refraction study at Ft. Scott, Kansas. I quickly identified Dr. Somers as one who is particularly willing and able to share his considerable expertise with an interested archaeologist, and Lew continues to play an important role in USACERL's efforts to infuse geophysical techniques into Army cultural resource management.

The success of this project is, in large part, due to the competence of the geophysical and archaeological research teams. Dr. Lewis Somers, Geoscan Research (USA), conducted the geophysical surveys at Ft. Riley. He was assisted in his 1996 fieldwork by David Maki and Dr. Fred Finney. Dr. Paul Kreisa, University of Illinois Public Service Archaeology Program (PSAP), directed the archaeological investigations. Gregory Walz and Todd Brenningmeyer conducted the site gridding and mapping. Lynn Richardson, Steven Wolverton, and Jameson Harwood (USACERL) assisted the geophysical and archaeological researchers on several occasions.

R. Eric Hollinger (University of Illinois, USACERL) collected and synthesized much of the data on the nature and cost of previous archaeological and geophysical investigations conducted in Kansas. Eric also provided useful input on many other aspects of this project. I have benefited from numerous conversations about this study with Dr. James Zeidler (USACERL), who conducted a parallel study at the Poinsett Electronic Combat Range, South Carolina.

Chapter 1

INTRODUCTION

Background

The 12 million acres of land managed by the U. S. Army contains thousands of archaeological sites. Federal law and Army regulation (NHPA, AR 200-4) require the Army to determine which sites are eligible for nomination to the National Register of Historic Places (NRHP). Traditional strategies for assessing the NRHP status of archaeological sites are expensive and unreliable. Since 1994, the U. S. Army Construction Engineering Research Laboratories (USACERL) Cultural Resources Research Center has been working to develop a cost effective and reliable strategy for NRHP site assessment based on the use of geophysical survey techniques and highly targeted ground truthing excavations (Hargrave and Zeidler 1997). In September, 1995, Ft. Riley requested the assistance of USACERL in conducting NRHP eligibility assessments of four archaeological sites. Ft. Riley Cultural Resources manager Dr. Richard Shields and archaeologist John Dendy (Dynamac Corporation, Ft. Riley) agreed to use the four site assessment project as an opportunity to compare the effectiveness of the traditional and geophysical strategies. Geophysical and archaeological investigations were conducted at 14RY3183 (the ForThree site), 14RY3193 (the Army City site), 14RY5155, and 14GE3108 (the Station Agent site) during April, May, and June, 1996.

Objectives and Report Organization

This monograph represents the final report on USACERL project BA5, "Archaeological and Geophysical Investigations at Ft. Riley". The objectives of this report include 1) a synthesis of the geophysical and archaeological investigations conducted at each site, and 2) an evaluation of the costs and benefits associated with use of the traditional and geophysical site assessment strategies. The report is organized as follows. Chapter 2 provides a brief overview of the NRHP eligibility criteria. Chapter 3 discusses limitations of the traditional site assessment strategy, with a focus on issues of cost and reliability. Chapter 4 provides a brief introduction to geophysics and summarizes previous efforts to incorporate geophysical techniques into the investigation of sites in Kansas. Chapter 5 reports the results of a controlled comparison of the two site assessment strategies. Finally, Chapter 6 summarizes the project rationale and findings, evaluates the costs and benefits associated with the two strategies, and provides recommendations for refining the geophysical strategy.

Chapter 2

NATIONAL REGISTER OF HISTORIC PLACES ELIGIBILITY CRITERIA

As the stewards of millions of acres of public land, Department of Defense (DoD) installations have a responsibility to manage a wide array of cultural resources, including tens of thousands of archaeological sites. Key legislation defining the historic preservation responsibilities of federal agencies includes the National Historic Preservation Act (NHPA) of 1966, as amended, the Archaeological Resources Protection Act (ARPA) of 1979, the Native American Graves Protection and Repatriation Act (NAGPRA) of 1990, and Executive Order 11593. AR 200-4 specifies Army policies, procedures, and responsibilities for meeting cultural resource management requirements (AR 200-4 October 1997).

The National Register of Historic Places plays a central role in the federal government's cultural resource management (CRM) program. Authorized by NHPA, the National Register is a listing of districts, sites, buildings, structures, and objects that played a significant role in American history, architecture, archaeology, engineering, and culture. Prior to the execution of a federally funded, assisted, or licensed undertaking, the sponsoring agency is required to make a reasonable and good faith effort to identify historic properties on or eligible for the National Register that may be adversely affected by the undertaking.

Efforts to identify archaeological sites are typically divided into several phases or stages, including an inspection of extant maps and records, and a pedestrian survey of the proposed project area. Sites must then be assessed as to their potential eligibility for nomination to the National Register. In many cases, a low density of artifacts, the absence of evidence for intact cultural strata, and/or the extent of previous adverse impacts clearly indicate that a site is not a viable candidate for the National Register. In other cases, however, it is necessary to conduct additional investigations to determine if a site is eligible for the National Register. These National Register site eligibility assessments generally involve a program of test excavations.

Eligibility Criteria

To be eligible for the National Register, an archaeological site must possess the qualities of significance and integrity. To be significant, a site must meet at least one of four criteria: Criterion A requires that a site be associated with events that have made a contribution to the broad patterns of U.S. history. Sites that are associated with the lives of significant historical figures may qualify under Criterion B. Criterion C pertains to those sites that embody the distinctive characteristics of a type, period, or method of construction, that represent the work of a master, possess high artistic

values, or represent a significant and distinguishable entity (USDI 1995).

Archaeological sites are most commonly eligible for the National Register under Criterion D. This criterion requires that the site have the potential to yield important information about human history or prehistory. Many sites can provide at least some information about history or prehistory. The importance of the information a site may yield must be assessed using an appropriate historic context. An historic context is a compendium of extant data and interpretations, organized by one or more themes (e.g., by time period, region, etc.). A site that cannot be related to a particular time period or culture-historical unit will not have a historic context and so cannot be eligible for the NRHP. Important information will, for example, allow researchers to better understand current gaps in existing knowledge, propose theories and/or test hypotheses that support or challenge conventional understandings, and so forth (USDI 1995:21-22). It is important to note that a site need not be nationally significant to be eligible for the National Register. Properties that are significant at a local, state, or regional level are also eligible. Also, individual properties can be relevant to more than one historic context. For example, a building erected during the earliest period of a military installation's history could also be relevant to one or more subsequent periods.

Once it has been determined that a site may be able to produce important information, it is necessary to develop a research design. The research design will identify particular, well-defined research questions, and will specify the type of data from the site that can be used to address those questions. The research design thus provides a basis for selecting the appropriate mix of investigative techniques to be used in the eligibility assessment. The objective of the eligibility assessment is to document that the information needed to address the specified research questions is present at the site.

Integrity

To be eligible for the National Register, a site must also possess integrity. Integrity is the condition or state of preservation or intactness that allows a site to convey it's significance. For a site that is eligible under Criterion D to have integrity, it must be sufficiently intact as to be able to yield the expected important information, assuming that the appropriate recovery techniques are employed. "For properties eligible under Criterion D, integrity is based upon the property's potential to yield specific data that addresses important research questions, such as those identified in the historic context documentation in the Statewide Comprehensive Preservation Plan or in the research design for projects meeting the Secretary of the Interior's Standards for Archeological Documentation." (USDI 1995:46).

The National Register eligibility guidelines recognize several aspects of integrity, including integrity of location, design, setting, materials, workmanship, feeling, and association. The aspects of integrity that are generally important for archaeological sites being evaluated under Criterion D are location, design, materials, and possibly workmanship. For example, a site with an intact sequence of cultural strata would have integrity of location. The presence of subsistence remains in association

with other artifacts diagnostic of a particular cultural historical unit would entail integrity of materials and association (USDI 1995:49).

Chapter 3

TRADITIONAL STRATEGIES FOR ASSESSING NATIONAL REGISTER ELIGIBILITY

To be eligible for the National Register of Historic Places (NRHP), an archaeological site must possess the qualities of significance and integrity. These concepts (as well as the role of historic contexts and research designs) were discussed in Chapter 2. The present chapter outlines the methods and approaches traditionally used in the field to recover data needed to assess the significance and integrity of an archaeological site. The focus here is on the cost and reliability of traditional approaches to NRHP eligibility assessments.

Published guidelines for applying the National Register criteria recognize seven aspects or qualities of integrity. An adequate evaluation of integrity requires a consideration of a property's physical features and how they convey it's significance (see Chapter 2). In practice, many archaeologists view the presence of intact cultural deposits as the minimal requirement for integrity of an archaeological site. Such deposits typically provide the contextual and chronological information needed to address a variety of research questions about settlement, subsistence, and other practices. Sites that represent very rare resource categories are sometimes viewed as eligible even if no intact deposits are present. For example, a lithic scatter comprised primarily of artifacts thought to date to the Paleoindian period might be viewed as eligible even if the site was restricted to the plow zone. Here there would be no intact cultural strata, but there could nevertheless be integrity of association among a set of functional (tool and debris) types distinctive of and informative about a particular time period. In most cases, however, archaeological sites must have intact horizontally extensive cultural strata (commonly, if imprecisely, referred to as midden) or discrete (horizontally restricted) features such as pits, postholes, or hearths in order to be viewed as eligible for the National Register. Simply demonstrating that such deposits are present does not represent an adequate argument for a site's eligibility. A site's relevance to important research questions must be demonstrated, not simply assumed. In terms of site assessment field strategy, however, the focus is on identifying intact cultural strata and features.

National Register assessments commonly include the use of several of the following field techniques: controlled surface collections (if surface visibility permits), the excavation of small shovel, posthole, or auger tests, and the hand excavation of a small number of test units. A few states (e.g., Illinois) require or strongly encourage the mechanical removal of the plowzone or topsoil to investigate a larger percentage of the total site area. In Kansas, the SHPO has disseminated written recommendations about the techniques that can and, in some cases, should, be used in National Register assessments of archaeological sites (Brown and Simmons 1987). A brief overview of these guidelines is provided here.

One approach to the delineation of site boundaries is the use of regularly spaced soil cores, posthole, or shovel tests to monitor the distribution of carbon, artifacts, and soil color. Controlled surface collections are advocated as the most reliable indicator of subsurface artifact distributions at sites located in agricultural fields if a) there has been little or no downhill movement, b) cultural disturbances other than agriculture have not occurred, and c) there has been minimal alluviation. All excavated soils must be screened through mesh not larger than .25 inch or carefully excavated by trowel. Test units are to be excavated using natural levels if possible. Consultation with a geomorphologist is advocated in order to determine what depth of excavation is appropriate. The horizontal placement of test units is left to the discretion of field director, and use of an intra-site sampling strategy to achieve a representative sample is suggested. The size of controlled surface collection units and test units is dependent upon site conditions, anticipated preservation, and the nature of the research questions being addressed, and is therefore left to the judgement of the archaeologist (Brown and Simmons 1987:8-9).

The Kansas SHPO guidelines note that "...resistivity surveys, magnetometry, and ground-penetrating radar may be very useful to delineate features that are not observable from the ground." It is also noted that "The generating of maps, showing low and high values, offers an alternative approach to excavation and can provide valuable information regarding the significance of a site" (Brown and Simmons 1987:8-10). In recent years, several projects in Kansas have included the use of geophysical techniques (see Chapter 4). However, most National Register assessments conducted in Kansas, as in other states, rely exclusively on the use of traditional techniques.

Reliability of Traditional Assessment Strategies

Traditional NRHP eligibility assessment strategies based on hand excavation commonly have two major limitations: they are unreliable and expensive. The reliability of a traditional site assessment is a factor of sample size and the nature of the cultural deposits present. It is common for NRHP assessments to involve the excavation of, at most, one percent of a site. The degree to which small sample size compromises the reliability of a site assessment depends largely on the nature of the cultural deposits present at the site. Some sites are characterized by the presence of a horizontally extensive midden or other intact (sub-plow zone) cultural strata. Horizontally extensive deposits may be identified even if the site assessment program involves nothing more than the excavation of several widely spaced test units. At many sites, however, all prehistoric living surfaces have long since been incorporated into the plow zone. But some of these sites include discrete subsurface features such as hearths, storage pits, and architectural remains. The upper portions of these features have, in many cases, been truncated by modern agricultural activities, but the lower portions often remain intact. Unfortunately, the laws of probability suggest that it is highly unlikely that any of these discrete features will be encountered by a small number of widely spaced test units, or even by a grid of evenly spaced shovel tests. For sites characterized by discrete features but no horizontally extensive cultural strata, the traditional site assessment strategy is highly unreliable.

Shott (1987) provides a more thorough examination of the effects of small sample size on the

reliability of traditional site assessments. He notes that "Features...pose special and acute sampling problems: they are integral to the evaluation of site significance, but they..." [are characterized by] "...complex distributions and are small relative to the surface area of most sites." A number of studies have demonstrated that there is not necessarily a correlation between the abundance of artifacts on the surface and the location of subsurface features (e.g., Synecki 1984). Thus, the likelihood of encountering at least one cultural feature in a site assessment is largely a result of probability theory. Shott notes that site assessments based on hand excavation typically expose less than five percent of a site (1987:365). Based on data from a small group of sites in the midwestern U.S., Shott suggests that at least seven percent of the total site area would need to be excavated to be at least 90% certain of encountering at least one feature (1987:363). Furthermore, at least 43% of the site would need to be excavated to ensure a reliable estimate of the number of features present. He notes that "nondestructive search methods" (i.e., geophysical techniques) offer a possible solution to the sampling problems, but warns that "Before this becomes practical on a large scale...equipment costs and the efficiency and reliability of methods in detecting small, ephemeral features in a variety of archaeological contexts must be determined" (Shott 1987:368). Shott therefore advocates the use of mechanized removal of the plowzone as the most reliable solution to the problems of site assessment reliability caused by small sample size.

Costs of Traditional Site Assessment Strategies

Traditional site assessments are expensive because they are labor intensive. Costs vary widely as a result of local and regional differences in labor rates (as codified in the Service Contract Act rates for federally funded projects), the nature and amount of work required, the complexity of archaeological sites, the amount of competition among contractors, etc. It is important, in the present cost-benefit study, to accurately document the actual costs of traditional National Register eligibility assessments in Kansas. To this end, an effort was made to collect data on a number of previous site assessments. This effort began with an examination of the collection of previously submitted site assessment reports maintained by the Kansas State Historical Society in Topeka. Each report judged to be relevant to this study was examined, and information pertaining to a number of topics was recorded.

Inclusion in this study required the availability of reliable information on project cost and the amount of excavation conducted. No attempt was made to adjust project costs for the effects of inflation. However, only projects conducted since 1990 were included. In some cases, project cost was estimated. For example, a single report might discuss the assessment of several sites and provide a total project cost, but not specify costs per site. In such cases, the total cost was simply divided by the number of sites included. This averaging may introduce some inaccuracy in terms of costs for individual sites, but does not impact the usefulness of mean values when a number of site assessments are considered together. Data on a number of other cost and level of effort factors were collected when available. Of particular relevance here are data on the total excavated volume of test units, the number of shovel, posthole, and/or auger tests, number of person days devoted to fieldwork and to the site assessment as a whole, and the cost per square meter of excavation.

Data on some of the factors specified above were collected for approximately 40 site assessments in Kansas. Fifteen of these cases were eventually deleted because information on one or more key variables was unavailable, or because the project occurred prior to 1990. Table 1 presents cost and level of effort data for 25 traditional site assessments. It is not known what percentage of all site assessments conducted in Kansas since 1990 is represented here. It is assumed that this sample represents a minority of the total, but is nevertheless sufficient to convey a realistic idea of typical costs and level of effort.

Total cost per site in the sample of 25 Kansas site assessments ranges from \$591.12 to \$21,318.70, with a mean of \$8,005.05. To some extent, this range in costs reflects variation in the amount of excavation. The total area exposed by test units ranges from .61 to 29.2 m^2, with a mean of 6.23 m^2. If the amount of excavation (area exposed by test units) explained most of the variation in total cost, one would expect to find few differences in the cost per m^2 (i.e., total project cost divided by area excavated). In fact, the cost per m^2 ranges from \$478.33 to \$2,531.38. The number of shovel tests excavated may, in some cases, account for some of the variation in cost per m^2. The areas exposed by the shovel tests are not included anywhere in the calculations discussed here, but the excavation of shovel tests clearly increases project costs. Unfortunately, not all of the site assessment reports state clearly how many shovel tests were excavated. Thus, the absence of any indication of shovel tests in Table 1 does not necessarily mean that none were excavated. For those 11 site assessments where shovel tests were reported, the number of tests ranges from 12 to 207, with a mean of 41.45. The site with 207 is clearly an outlier, and if one deletes it, the mean is 24.9. Finally, the number of person days devoted to fieldwork as well as to a project as a whole should clearly be correlated with project cost. In the sample discussed here, person days in the field range from 1 to 72, with a mean of 24.88 (n=17). Total number of person days per project range from 2.75 to 107, with a mean of 44.86 days.

In summary, traditional National Register assessments conducted in Kansas since 1990 generally involve the excavation of test units exposing approximately 6 m^2 and, in many cases, about 20 shovel tests. Project costs average just over \$8,000. per site. The area exposed by the test units represents a very small percentage of total site area. The traditional assessment strategy is therefore not reliable when applied to sites that may have at least some discrete, subsurface features, but which lack a horizontally extensive cultural stratum.

Table 1. Cost and Level of Effort Data for Previous Traditional Site Assessments in Kansas.

Site	NRHP Eligible?	TU Area (m^2)	TU Volume (m^3)	Shovel Tests (n)	Field Days (n)	Total Days (n)	Total Cost ($)	Cost ($ per m^2)
14CO349	no	6.00	2.50		30.00	60.00	9868.64	1644.77
14CO351	no	6.00	2.60	38	30.00	60.00	9868.64	1644.77
14CO352	no	5.00	1.60		30.00	60.00	9868.64	1973.73
14CO353	no	5.00	1.60		30.00	60.00	9868.64	1973.73
14CO354	no	5.00	2.80		30.00	60.00	9868.64	1973.73
14CO365	no	5.00	2.20		30.00	60.00	9868.64	1973.73
14CY407	no	0.61	0.27		1.00	2.75	591.12	969.05
14JO51	no	4.00	1.20				1913.33	478.33
14JO429	no	2.00	0.50				956.67	478.33
14BO2466	no	1.00	0.30				993.60	993.60
14SH342	no	5.00			15.00	37.50	4806.75	961.35
14CO343	no	5.00	2.60		26.94	43.69	6488.00	1297.60
14CO344	no	4.00	2.04		26.94	43.69	6488.00	1622.00
14MY2336	yes	29.20			72.00	107.00	17386.87	595.44
14PH330		3.00	2.34		25.00		7594.14	2531.38
14GR333	no	5.00	2.20	21	33.38	47.63	6866.08	1373.22
14RY5109	no	3.00	1.00	57			3500.01	1166.67
14RY5129	no	7.00	2.30	23			8166.67	1166.67
14RY5131	no	7.00	2.70	12			8166.67	1166.67
14RY5144	no	6.00	1.90	207			7000.00	1166.67
14RY5157	no	7.00	3.90	31			8166.67	1166.67
14RY3183 (a)	yes	11.00	6.60	21	22.68	31.25	21318.70	1938.06
14RY3193 (a)	?	8.00	2.90	12	9.94	10.63	7318.37	914.80
14RY5155 (a)	no	8.00	3.00	14	10.06	13.31	9171.65	1146.46
14GE3108 (a)	?	8.00	4.60	20	11.63	20.35	14020.99	1752.62
Mean		**6.23**	**2.33**	**41.45**	**25.56**	**44.86**	**8005.05**	**1362.80**

Notes:

(a) This site included in the present cost benefit study.

Chapter 4

GEOPHYSICS IN ARCHAEOLOGY

Geophysics is that branch of the earth sciences dealing with physical processes and phenomena in the earth. Geophysical techniques have been used by archaeologists for more than 50 years (Heimmer and DeVore 1995:1). A number of overviews of geophysical techniques relevant to archaeology are available (e.g., Clark 1990, David 1995; Ebert 1984, Gaffney et al. 1991, Heimmer and DeVore 1995, Weymouth 1986, and Wynn 1986), and no attempt will be made to reiterate these here. It is useful, however, to provide a little basic information about the techniques used in the USACERL cost-benefit study. Similarly, it is useful to discuss a few issues of survey design.

Geophysics is much better integrated into archaeological research in Great Britain and Europe than in North America. In Europe and Great Britain, many archaeological sites include substantial architectural remains and abundant metal artifacts. These materials were relatively easily detectable by early geophysical instruments, and this contributed to the early acceptance of geophysics by Old World archaeologists. In contrast, North American sites tend to be much more ephemeral. Prehistoric architectural remains and other features are generally manifested in the archaeological record by relatively subtle differences in soil color and texture. Stone architecture does not occur in many regions, and metal artifacts are, for all practical purposes, absent at prehistoric sites. The low contrast between cultural deposits and the surrounding matrix results in a relatively weak response to geophysical survey methods. Also contributing to the weak response is the relatively small size of the cultural features (pits, postholes, hearths) characteristic of most North American prehistoric sites. At historic sites the contrast may be much greater and architectural features tend to be much larger. Thus, survey design for historic sites is less critical than for prehistoric sites (Somers 1998).

In conducting a geophysical survey, a basic goal is to maximize the response from the cultural record while minimizing statistical uncertainty. The principal sources of statistical uncertainty are 1) field methods, 2) sensor selection, and 3) site environment (geology, modern trash, post-occupational soil disturbances, etc.). The number of data samples collected per square meter (N) is the principal consideration in efforts to minimize the statistical uncertainty and simultaneously maximize the archaeological signal. In a simple additive signal mode, the greater the value of N, the better the archaeological signal can be represented. Simultaneously, the greater the value of N, the smaller the statistical uncertainty associated with the map (background) areas surrounding the archaeological features. The mathematical effect is to increase the archaeological signal proportional to N and reduce the statistical uncertainty of the background by the square root of N. Archaeological feature detection and interpretation both benefit as the signal to noise ratio is increased. These concepts result in a strong pressure to use instruments with low noise, high data sample rates, and

large memory. They also create strong pressure for high data sample density in archaeological surveys, high- and low-pass filter data processing of survey data, and a number of different image-like data display methods (Somers 1998).

Resistivity

For archaeological applications, the most versatile and cost-effective geophysical techniques include resistance, magnetics, and ground penetrating radar. The resistivity method is the most widely used of the electrical geophysical methods. Resistivity methods can identify archaeological features that differ from the surrounding matrix in terms of moisture, ion concentrations, and soil types. These methods measure differences in the relative inability of materials to conduct an electrical current. A small electrical current is introduced into the earth in the general vicinity of the survey area, and data values (measured in ohms) are recorded at regular intervals. Four probes are used to measure variation in resistivity. One pair of probes introduces the current while the second measures the decrease in voltage. Changing the arrangement (array) of the probes allows one to study different aspects of resistivity (Gaffney et al. 1991:2; Somers 1998).

Over the past 20 years, most archaeological applications of the resistivity method have used the twin probe or twin electrode array (Gaffney et al. 1991:2). Twin electrode resistance equipment, in contrast to electromagnetic instruments, does not respond to buried pipes or other metal, does not generate a background signal dependent upon the height of the instrument above the surface, and the depth of the survey is easily adjusted in the field. Current instruments (such as the Geoscan Research RM-15) offer automated logging of both data and data sample location and the ability to process and display data on portable computers in the field. Thus, the surveyors have access to high quality maps at the site during the survey (Somers 1998).

The resistivity method is characterized by several potential disadvantages. The method is not suitable for situations where the soil is water saturated. Use of a resistivity instrument involves insertion of probes into the ground at each point where data are collected, with the result that the rate at which an area can be surveyed is slower than that achieved in magnetic (e.g., gradiometer) surveys. Also, like the other geophysical techniques, resistivity may not detect very small and/or low contrast targets.

The depth of a resistivity survey depends on the spacing of the probes. David (1995:28) notes that "...a mobile probe spacing of 0.5 m is now standard, giving a depth of penetration of approximately 1.0 m. Where features are more deeply buried, the probe spacing should be widened, although widths of over 1 m will usually result in multiple peaks and an unacceptable loss of definition. For sites with deeper stratigraphy, surveys conducted at two or more probe spacings have the potential to add useful insights on the distribution of features at different levels." A closer spacing of the probes will reduce the depth of survey but will enhance the potential image resolution of subsurface features (Clark 1990:57).

Magnetics

Magnetic methods are based upon localized disruptions in the earth's magnetic field. Magnetic techniques can identify archaeological features and artifacts which are magnetically differentiated from the surrounding matrix. The archaeological record can have an increased magnetic susceptibility or a remnant (permanent) magnetization. The former is usually associated with human disturbances of the soil. For example, a pit excavated into the subsoil may be filled with topsoil, which generally has a higher iron oxide content and magnetic susceptibility than the subsoil. Increases in remnant magnetization are typically associated with fired soils, ceramic objects, certain rocks, and iron objects (Somers 1998).

Proton magnetometers have been used in archaeological studies since the 1950s. Proton-precession and fluxgate (gradiometer) magnetometers are now in wide use. A gradiometer has two magnetic sensors or magnetometers separated by a fixed distance (.5 m). Whereas a survey using a single magnetometer is likely to be corrupted by modern iron trash, a gradiometer is less severely compromised by modern iron objects as well as the effects of diurnal variations, magnetic storms, power lines, and regional gradients (Geoscan Research 1993). Current instruments (such as the Geoscan Research FM-36) offer automated data logging and fully integrated software, thus providing convenient data collection, processing, and display on portable computers in the field (Somers 1998). Magnetic instruments, particularly gradiometers, allow relatively rapid survey coverage per unit area (Clark 1990:78).

There is an inverse relationship between depth and sensitivity in a magnetic survey. Clark (1990:78-79) describes this relationship (using an example from Great Britain) as follows: "...for a total field instrument such as a single sensor proton magnetometer...and a 0.5 meter (1.6 ft) fluxgate gradiometer...there is a rapid fall-off in sensitivity...between 1 and 2 m...and by 3 m (10 ft) the limit of detection is effectively reached for most features" (1990:78). At that depth, the anomalies associated with a typical pit or kiln feature could not be detected against the background data values. Conversely, sensitivity increases substantially at depths less than one meter.

There is also an inverse relationship between the horizontal distance between data reading points and the image resolution that can be achieved. Clark (1990:81) notes that "...a reading interval of 0.5 m (1.6 ft) is the largest suitable for detailed recording, and there is a further gain in resolution at 0.25 m (10 in), four readings per metre. Going to 0.125 m (5 in), eight readings per metre, produces only a marginal improvement on this".

Ground Penetrating Radar

Radar instruments include an antenna which contacts the ground surface and sends and receives a low frequency electromagnetic signal into the earth. The reflected signal is then compared to the original input. The manner in which the signal is reflected or attenuated, as well as its

magnitude or amplitude, phase (negative or positive), and frequency provides information about the nature of the subsurface materials. Radar can provide cross sectional maps that are informative about soil strata, bedrock, buried objects, and cavities or voids (including cultural features). Current radar instruments and supporting software allow the operator to view survey results on a computer screen as the survey is underway.

Archaeological applications of GPR are presently characterized by several limitations (Heimmer and De Vore 1995:42; David 1995:25). GPR systems are relatively expensive, and the interpretation of survey results requires specialized software and considerable expertise. Site conditions such as saturated soils or highly conductive clay soils can dramatically restrict the depth of penetration that can be achieved. An uneven ground surface can complicate data interpretation. Similarly, reflected signals passing through the air (from incompletely shielded antennas) can obscure signals from subsurface phenomena. Furthermore, "...on archaeological sites the distribution of material of differing electrical properties is often complex and can make the radar data confused..." (David 1995:27). As with resistivity and magnetic techniques, the resolution obtainable using GPR is inversely related to survey depth.

Previous Uses of Geophysics at Kansas Archaeological Sites

Geophysical techniques have been used in a number of archaeological investigations in Kansas. Unfortunately, reports on most of these efforts were either not prepared or not widely distributed. The following section provides a brief summary of many of the previous geophysical archaeological studies in Kansas. Much of this information was provided by the Kansas State Historical Society (in personal communications to Eric Hollinger, March 1996), and by geophysicist Bruce Bevan, who is compiling an annotated bibliography of reports on geophysical surveys conducted throughout the U.S. (Bevan n.d.).

In 1972, Paul Ferguson conducted a very brief geophysical survey of a portion of the Hill Site (14MM21), located in Miami County, east central Kansas. The instrument used was described as a "soil anomaly detector". Several anomalies were found to correspond to small limestone rocks and rusted farm machine parts. The single large (2 by 4 m) anomaly judged as worthy of more extensive investigation proved to correspond to a relatively dense concentration of lithic debris and charcoal, but no discrete feature was identified (KSHS, personal communication, March 1996).

In 1979, Donald Blakeslee and Arthur Rohn (Wichita State University) sponsored a proton gradiometer survey at the Hillsdale Lake site (14MM1C). The survey located concentrations of limestone and identified the exact location of a Catholic Mission to the Miami Indians near Paoli, Kansas (Bevan n. d.; Myers 1979:364).

In 1980, the National Park Service conducted a proton magnetometer survey at 14M1417, an Upper Republican habitation site located in Mitchell County, north central Kansas. Located in a cultivated field, the site included a number of earth lodge structures. Ground truthing excavations

were not particularly successful in locating features associated with magnetic anomalies. An underground pipeline present at the site was reportedly not identified by the survey (KSHS, personal communication, March 1996).

In 1992, several geophysical techniques were used at the Sharpes Creek site (14MP408), a Great Bend aspect site located in McPherson County, central Kansas. This work was sponsored by the Kansas State Historical Society. A proton magnetometer survey was conducted by Bob Nickle, Bruce Jones, and Jan Dial-Jones of the Midwest Archaeological Center, National Park Service. The magnetometer survey did not locate any anomalies that clearly suggested hearths or pits, but several paired (moderately high with moderately low) anomalies were viewed as possible features that warranted investigation (Jones n. d.; KAAN: March 1993). Additionally, a ground penetrating radar survey was conducted by George Butler and Associates (Stein 1992; KAAN July 1992). Oakfield cores were used to ground truth some of the anomalies and a number of pit features were reportedly located in this manner.

In 1991, John Weymouth (University of Nebraska) conducted a proton magnetometer survey at the Quarry Creek site (14LV401), located at Ft. Leavenworth, northeastern Kansas. This work was conducted in conjunction with the KU-KSU archaeological field school directed by Brad Logan (Kansas University) and John Hedden (Kansas State University). The site includes a Kansas City Hopewell occupation dating ca. 170-370 A.D. The magnetic survey covered an area of 1,550 m^2, took two days, and was conducted using two Geometric G856 proton magnetometers. One instrument was used as a reference and the other collected data 40 cm above the ground surface at one meter intervals. Data values were recorded by hand and subsequently entered into a computer. Line contour and gray-scale maps were then generated. Subsequent excavation revealed that five anomalies were prehistoric features, seven contained historic metal, and one anomaly contained brick. Three anomalies were located near preexisting holes, one anomaly was spurious, and four proved to be negative (i.e., no evidence of cultural origins). (Bevan n.d.; Majewski 1993:568).

In 1992, Weymouth (University of Nebraska) conducted a magnetic survey at the White Rock site (14JW1), located at Lovewell Reservoir, Jewell County, north-central Kansas (Logan et al. 1993). This survey was sponsored by the Bureau of Reclamation and Kansas Museum of Anthropology (Bevan n.d.). This late prehistoric (Oneota) site measured approximately 180 by 200 m. Two Geometric G-856 magnetometers were used to survey a total area of approximately 900 m^2. A Bison Magnetic Susceptibility Bridge indicated that the susceptibility of the surface soil was rather low, suggesting that anomalies related to earthen features such as hearths and pits would be weak. Seventeen anomalies were identified. A total of 10 m^2 was excavated to investigate five of the anomalies. One of the anomalies proved to be related to two features (a hearth and a postmold).

In 1994, a magnetometer survey was conducted by Ken Neuhauser (Ft. Hays State University) at site 14CO501, in Arkansas City, Kansas. The surveys revealed no anomalies attributable to non-recent cultural activity (Neuhauser N.D.).

In 1994, Weymouth (University of Nebraska) conducted a geophysical survey for the Bureau of Reclamation at two intaglio sites in Kansas (Bevan n.d.).

In 1997, the National Park Service conducted a course in the use of geophysical and related techniques at Ft. Scott, Kansas. Organized by Steve De Vore, the course was taught by Bruce Bevan, Rinita Dahlin, Steve De Vore, Lewis Somers, John Weymouth, and others. As is the usual practice for the course, a number of techniques including resistivity, magnetics, ground penetrating radar, and seismic refraction were used to investigate the same survey area. Bevan has distributed an account of the seismic refraction study, and reports of the other surveys are in preparation (Bevan 1997).

On balance, Kansas has a fairly long but, unfortunately, incompletely reported history of efforts to integrate geophysical survey techniques into archaeological investigations. Most of the geophysical surveys conducted thusfar have used magnetometers, although the 1997 work at Ft. Scott used a variety of techniques. The surveys conducted by Weymouth in conjunction with archaeological investigations by Logan et al. are the most directly comparable to the present effort to integrate geophysics into the NRHP site assessment process. The previous geophysical investigations cited here have provided a foundation for a more widespread use of geophysics at Kansas archaeological sites. These studies do not, however, provide the detailed cost and level of effort data needed to conduct an objective comparison of the geophysical and traditional site assessment strategies.

Chapter 5

TRADITIONAL AND GEOPHYSICAL SITE ASSESSMENTS AT FT. RILEY

This chapter reports the results of traditional and geophysical NRHP assessments of four sites at Ft. Riley, Kansas. These investigations provide an empirical basis for a comparison of the costs and benefits associated with the two site assessment strategies. A parallel study involving two sites (one prehistoric and one historic) was conducted at the Poinsett Electronic Combat Range, an Air Force installation located in South Carolina (Kreisa et al. 1996; Somers 1997; Zeidler 1997).

Four sites (two prehistoric and two historic) were selected for the comparative study by the Ft. Riley cultural resource manager and the author from a list of candidates compiled by the former. A contract for the geophysical study was awarded to Dr. Lewis Somers, Geoscan Research (USA). The contract for the traditional site assessments was directed to the Public Service Archaeology Program (PSAP), University of Illinois at Urbana-Champaign, via an extant Indefinite Delivery Indefinite Quantity contract. The field investigations proceeded as follows. First, PSAP established a grid and prepared plan maps for each site. Geoscan then conducted the geophysical surveys. Next, PSAP conducted the traditional site assessments with no information about the results of the geophysical work. PSAP was then provided with a list of coordinates of geophysical anomalies selected for ground truthing investigations. Even at the stage of report preparation, PSAP was not provided with information about the results of the geophysical surveys. This was intended to ensure that the PSAP investigation would be representative of the traditional approach to site assessment.

Estimation of Cost Factors

The project scopes of work required the geophysical and archaeological contractors to record detailed data on the time allocated to various tasks. In their report on the archaeological component of the Ft. Riley study, Kreisa and Walz (1997:137) specify the number of hours devoted to surface collections, shovel tests, preparation of site plan maps, test unit excavation, artifact processing and analysis (see Table 2). Time spent in preparing the project research design, monthly and interim reports, and the summary report is not indicated. PSAP was not requested to differentiate time spent processing and analyzing artifacts recovered from the anomaly tests vs. those from the traditional excavations. In the present study it is assumed that the amount of time devoted to artifact processing and analysis was proportional to the number of artifacts. For example, if a total of 100 hours was devoted to the artifacts, and 10 percent of the artifacts were from the anomaly tests, it is assumed here that 10 hours (10% of the total) was devoted to the anomaly test artifacts. To estimate the total hours devoted to the anomaly testing, hours spent excavating the anomaly shovel tests were added to those spent processing and analyzing artifacts from those tests.

Data on project costs reported by Kreisa and Walz (1997:137) are presented in hours rather than dollars. Hours are translated into dollars on a proportional basis. For example, Kreisa and Walz (1997) indicate that a total of 690.5 person hours were devoted to field and lab work for the four project sites. Total cost for the archaeological component of the project was $59,465. Thus, if a particular activity required 69 hours (approximately 10% of the reported total), it is assumed here that it required 10% of the total cost (approximately $5,946). Note that costs associated with all aspects of the report write-up are included in the fieldwork and analysis costs. In other words, the $5,946 mentioned above includes a "pro-rated" portion of the write-up costs.

Estimated costs associated with the geophysical survey are also converted to dollars in a proportional manner. The entire cost of the 1996 geophysical survey was $24,000. Major components of the work included the survey field work, data analysis and interpretation, and report preparation. As a general rule, analysis, interpretation, and report preparation require about two days for each day of field work. No attempt has been made here to account for inter-site differences in the ratio of field to post-field days. The area surveyed provides a better basis for estimating dollar costs than does the number of field days. This is because the geophysical fieldwork included some time devoted to training several individuals in the use of the equipment. Similarly, GPR was used to a limited extent at two sites. A final noteworthy factor in estimating dollar costs per site is the inclusion of site 14RY193. The statement of work for the geophysical investigations required surveys to be conducted at the four sites where the traditional assessments were to be conducted. Following completion of geophysical investigations at the four sites, a resistance survey was conducted at an extra site, 14RY193. This site was of particular interest to Ft. Riley and was slated for a traditional site assessment as a part of a separate project. Somers conducted the fieldwork at 14RY193 and prepared a draft map of the site. However, he was not requested to include this extra site in his final report. Thus, the estimated dollar costs for work at 14RY193 are actually a little too high, because they assume that part of the report preparation time was devoted to that site. The impact of this factor on the accuracy of the dollar cost estimates is, however, negligible.

Cost of Traditional Assessments at Ft. Riley

The total cost of the traditional National Register eligibility assessment at each of the four sites ranged from $7,318.37 (at 14RY3193) to $21,318.70 (at 14RY3183). The mean cost per site of the four traditional assessments conducted in this study was $12,957.43. These figures do not include the estimated costs of the anomaly testing. Table 2 shows the breakdown of estimated cost in hours and dollars by activity. Site 14RY3183 has the greatest estimated cost because it required the greatest number of hours (250) of field and lab time. In contrast, the least expensive assessment (14RY3193) involved only 103 hours, or only about 40% as much time as 14RY3183. Table 3 provides a partial explanation for this difference in the time expended at the two sites. Here one sees that a total of 11 m^2 was excavated at 14RY3183 whereas only 8 m^2 was excavated at 14RY3193 (as well as at the other two sites). Artifacts were much more abundant at 14RY3183 than at the other sites, and this is reflected in the number of hours devoted to processing and analysis: 68.5 hours at 14RY3183 compared to only 23.5 hours at 14RY3193 (Table 2). Finally, the cultural deposits at

14RY3183 were deeper and much more complex than at the other sites. This can be seen when one divides the total number of hours devoted to test unit excavation by number of square meters excavated. At 14RY3183, 14.9 hours were required to excavate each square meter, whereas the other sites had much lower ratios (14GE3108=9.69 hrs/ m^2, 14RY3193=8.88 hrs/ m^2, 14RY5155=6.94 hrs/ m^2).

Cost of Geophysical Assessments at Ft. Riley

The total cost of the geophysical component of the cost benefit study was $31,635.29. This total is the sum of the actual cost of the geophysical surveys ($24,000) and the estimated costs of the anomaly testing ($7,635.29). If one divides the total cost ($31,635.29) by five, the mean cost per site is $6,327.06. Costs per site range from $2,782.61 (for 14RY193) to $11,913.43 (14RY3193) (Table 4). The wide ranges in cost per site reflect the amount of geophysical survey and number of anomaly test shovel probes. For example, the cost of geophysical assessment at 14RY193 is very low because only one technique was used (resistivity), only eight 20 x 20 m grids were surveyed, and no anomaly testing was done. Similarly, relatively few grids (n=12) were surveyed and no anomalies were investigated (none were present) at 14RY5155. In contrast, the geophysical assessment costs were relatively high at 14RY3193 because 21 grids were surveyed and 43 shovel tests were excavated to investigate anomalies.

To avoid misconceptions about the cost per site of the 1996 geophysical assessments, it is important to keep several factors in mind: 1) These figures do include the costs of anomaly testing, but anomalies were investigated at only three of the five sites. 2) As will be discussed, the amount of anomaly testing was not fully adequate. 3) Site 14RY193 was an "extra" site, and the amount of geophysical work conducted there was not comparable to the other four sites.

Nature and Results of the Ft. Riley Traditional Assessments

Four sites were included in the Ft. Riley cost-benefit study: 14RY3183 (ForThree site), 14RY3193 (Army City), 14RY5155, and 14GE3108 (Station Agent site). These sites are all located within or very near the cantonment, in the extreme southeastern portions of Ft. Riley, Riley and Geary Counties, Kansas. A fifth site, 14RY193 (Thomas R. Hair site), was "extra" in that it was not required by the scope of work. Unlike the other four sites, 14RY193 is located in the extreme northern portion of the installation (Figure 1).

14RY3183

Site 14RY3183 (the ForThree site) occupies a narrow terrace overlooking the confluence of Forsyth and Threemile creeks (Figure 2). The site is located near a heavily developed portion of the cantonment and has been adversely impacted by the construction of a gravel road and installation of utility poles, a sewer, and a gas pipeline, as well as erosion along the slopes. Archaeological investigations conducted at the site in 1994, 1995, and 1996 included shovel probes, postholes, and

hand excavated test units. This work revealed the presence of at least three prehistoric components. The uppermost component represents the Smoky Hill Variant of the Plains Village Middle Ceramic Period. Two features are associated with a Smoky Hill occupation of the site: a linear concentration of daub interpreted as the remains of a structure, and a concentration of rock slabs, ash, and other burned debris interpreted as a hearth associated with the structure. A stratigraphically intermediate component is indicated by Scallorn-like projectile points and Kansas City Hopewell-like ceramics. The lowermost component is believed to date to the Late Archaic period (Kreisa and Walz 1997:132; Richardson 1997; Richardson et al. 1997).

Soils at 14RY3183 are mapped as Reading silt loam, 1-3 percent slopes (Jantz et al. 1975). Reading soils are included in the Smolan-Geary soil association. The deep, gently sloping to sloping silt loams and silty clay loams of this association occur on high terraces and uplands. Reading series soils were formed in alluvial sediments and are restricted to small bottomland terraces. A typical profile for Reading soils is as follows: an A horizon comprised of dark grayish brown (10YR4/2) silt loam extends to about 28 cm below surface (bs). Below this is a B horizon comprised of a dark grayish brown (10YR4/2) light silty clay loam extending from approximately 28 to 51 cm bs. A Bt2 horizon consisting of a dark grayish brown (10YR4/2) heavy silty clay loam extends from about 51 to 102 cm bs. Archaeological investigations at the ForThree site encountered a soil profile very similar to the one described here (Jantz et al. 1975; Kreisa and Walz 1997:65).

The traditional site assessment conducted by PSAP at the ForThree site included the excavation of six test units that exposed a total area of 11 m^2 (Table 3). Fourteen shovel tests were also excavated. Assuming that these measured .45 by .45 m, the 14 shovel tests exposed an additional 2.84 m^2, bringing the total excavated area to nearly 14 m^2. This represents approximately .0003 of the total site area. Nine of the shovel tests were negative, but a total of 144 artifacts were recovered in the five positive tests. The test units yielded a total of 3,105 artifacts (Kreisa and Walz 1997:66-74).

No evidence of discrete subsurface features such as pits or hearths was revealed by the PSAP traditional excavations. However, most of the test units encountered a 20 to 25 cm thick A2 horizon interpreted as an intact prehistoric midden. This was manifested as a very dark gray silt or sandy silt loam characterized by a relative abundance of artifacts (Kreisa and Walz 1997:67-72).

The recovered artifact assemblage included a total of 3,249 items. The assemblage was dominated by lithic items, primarily waste flakes and debris (n=3,189; 97%). Historic items represented the second most common category (n=60; 1.9%), followed by prehistoric ceramics (34; 1%) and other items (including faunal remains) (n=8). The lithics included several diagnostic (Scallorn Cluster and Washita type) projectile points, six biface fragments, and several retouched tools. Virtually all of the lithic artifacts represent the local Florence chert (Kreisa and Walz 1997:74-77).

The prehistoric ceramic assemblage consisted of 34 sherds. Nearly all of the specimens were small and weathered, making their assignment to extant types somewhat tentative. Nevertheless, four

distinct culture historical units representing the Early and Middle Ceramic Periods appeared to be represented: the Smoky Hill variant, the Valley Focus, the Schultz phase, and the Cuesta phase (Kreisa and Walz 1997:79-81).

The modest assemblage of historic artifacts was dominated by coal and slag (n=27), bottle glass, wire and machine cut nails, and several other metal items including buckle parts. These materials may be related to the nearby Packer's Camp (Kreisa and Walz 1997:82). The composition of the historic items recovered at the ForThree site did not appear to reflect a historic habitation.

The vertical distribution of prehistoric sherds and historic artifacts suggested that, despite the apparent lack of plowing, the upper 30 cm of deposits were somewhat disturbed. Sources of this disturbance may include pedestrian (human and mule) traffic across the site in the later 19th century, as well as earth moving associated with the recent construction of a gravel access road and the installation of utility poles and underground lines. Despite these impacts, PSAP's traditional investigation at the ForThree site did document the presence of an undisturbed prehistoric midden stratum between 30 and 60 cm bs. Other investigations at the site (Richardson 1997, Richardson et al. 1997) indicate the present of a Smoky Hill structure and hearth complex in the upper 30 cm, as well as deeply buried cultural deposits (Johnson 1996).

The results of the traditional site assessment indicated that the ForThree site retains integrity and can provide information relevant to a number of important research questions. The recovery of temporally diagnostic projectile points and ceramics in good depositional context indicated that the site can contribute to a refinement of the local Early and Middle Ceramic subperiod chronology. The PSAP investigations did not encounter carbon specimens suitable for radiocarbon dating, but previous excavations (Richardson 1997) did document that such materials are present at the site. Kreisa and Walz (1997:85) noted that the ForThree site also appears to represent a source of information relevant to a number of other important research questions, including intra-site patterning, trade, and the site's role within the local settlement system. Given these findings, the traditional assessment conducted by PSAP resulted in a recommendation that the ForThree site is eligible for the National Register.

14RY3193

The Army City site (14RY3193) is located between Camp Funston and Ogden, within a heavily developed portion of the cantonment. The site is situated on a level terrace of the Kansas River floodplain. During and shortly after the first world war, 14RY3193 was the site of a large, privately owned commercial complex designed to provide entertainment and other services to the Ft. Riley troops. The Army City complex included theaters, pool halls, saloons, banks, barber shops, restaurants, stores, sidewalks, and paved streets. A portion of the complex was destroyed by fire in 1920, and the remaining buildings were dismantled or relocated several years later (Rion 1960). At present, the Army City site lies in a grassy field, with few indications of the buildings and roads present there 75 years ago. The site margins may have been adversely impacted by the construction

of an earthen levee as well as the segment of Fourth Street connecting Camp Funston with Huebner Drive. There is, however, no evidence that the site has been plowed subsequent to construction of the Army City complex.

Soils at Army City are mapped as Muir silt loam, 0-1% slopes (Jantz et al. 1975). The Muir series is part of the Eudora-Haynie-Sarpy soil association. The deep and nearly level silt loams, very fine sandy loams, and loamy fine sands of this association occur on floodplains and terraces. Muir silt loams developed in deep alluvium on creek and river terraces. Jantz et al. (1975) describe a typical Muir soil profile as follows: an A horizon of grayish-brown (10YR5/2) silt loam extends to approximately 46 cm bs. Below this, a B2 horizon comprised of grayish-brown (10YR5/2) heavy silt loam extends to 107 cm bs. Test excavations conducted at Army City by PSAP in 1996 found no evidence of alluvial deposits resulting from the 1951 flood (Kreisa and Walz 1997:94).

The traditional assessment of the Army City site conducted by PSAP included the excavation of 12 shovel tests and four test units (Figure 3; Table 3). Assuming that the shovel tests measured .45 x .45 m, they exposed a total area of 2.43 m^2. The four 2 x 1 m test units exposed an additional 8 m^2, bringing the total to 10.43 m^2. This represents about .0016 of the portion of the site investigated by PSAP (and a much smaller portion of the overall site) (Kreisa and Walz 1997:87-89).

Three of the 12 shovel tests were positive, yielding a total of three artifacts (all wire cut nails). The four test units recovered a total of 164 items. Two soil strata were identified in each unit. Most of the artifacts were recovered in the upper stratum, which extended to a depth of 20-25 cm bs. A very few additional artifacts were recovered in the lower stratum, at depths ranging from 20 to 40 cm bs (Kreisa and Walz 1997:89).

No discrete subsurface features such as pits or architectural remains were identified in the traditional site assessment. One zone of compact soil was identified in the A horizon of TU 3. This compacted zone had a maximum thickness of 20 cm, was similar in color to the surrounding soil, and was not characterized by any concentration of artifacts. This test unit was positioned so as to investigate a circular vegetation pattern. Kreisa and Walz suggest that this pattern (and by implication, the compacted zone) may be related to this portion of the site's use as a truck driver training area in the 1980's (1997:89).

All but one of the 167 artifacts recovered by the traditional assessment date to the Historic period. Wire cut nails were most abundant (n=57), followed by coal/cinders (n=42), bottle glass (n=31), and flat glass (n=9). Less frequent artifact categories included unidentified metal (5), unidentified other (4), limestone (3), and undecorated whiteware (Kreisa and Walz 1997:95). Overall, the recovered artifacts reflect a predominance of non-domestic activities. Only two items, a piece of whiteware with a maker's mark, and a piece of amethyst or manganese glass, provide direct chronological information. The former was manufactured in 1913, whereas the latter dates to the period 1880 to World War I (Kreisa and Walz 1997:94-98).

The traditional assessment of the Army City site did not allow a final determination of the site's eligibility for the National Register (Kreisa and Walz 1997:98-100). One criterion for eligibility, the ability to determine date of occupation, was met in that the artifacts recovered were compatible with the World War I era. The test units and shovel tests included in the traditional assessment did not reveal clear evidence for discrete subsurface features. However, the presence of artifacts within an unplowed A-horizon could well be viewed as intact deposits, depending upon the nature of the demolition processes used to remove Army City. It is the absence of a site-specific historic context that places the greatest restrictions on an evaluation of the site's National Register status. The Scope of Work under which PSAP conducted the Army City site assessment did not require a documents search or oral history. Given the lack of any site plan data other than the 1917 and 1919 maps of the installation which show the location of a number of buildings, it is impossible to fully assess the potential research value of the recovered artifact assemblage. A detailed site plan (if one exits) would have allowed the traditional test units to be targeted on particular buildings, thereby providing more useful data on the integrity of architectural remains, architectural differences in the black vs. white facilities, etc. Finally, the traditional assessment was simply too limited in scale to provide data representative of the site as a whole. For these reasons, Kreisa and Walz (1997:100) recommended that additional investigations (including a documents search and possibly an oral history) be conducted prior to a final determination of the site's eligibility for nomination to the National Register.

14RY5155

Site 14RY5155 is located near the confluence of Deep Canyon and Threemile Creeks in the southeastern portion of Ft. Riley (Kreisa and Walz 1997:100). The site is situated on a fairly level terrace, within a portion of the original cantonment that has seen relatively little development. Prior to it's discovery, the site was seriously impacted by the removal of up to 30 cm of topsoil for use as fill. At the onset of geophysical investigations, most of the site area was devoid of vegetation and the surface was characterized by subtle dips, rises, and gouges created by the bulldozer. Marginal portions of the site were within a floodplain hardwood forest. Soils at 14RY5155 are mapped as Reading silt loam, 0-1% slope (Jantz et al. 1975). A description of a typical Reading soil series profile has been provided in the discussion of site 14RY3183.

14RY5155 was initially recorded in 1996 during a pedestrian survey by LTA, Inc (Larson and Penny 1996:137). At that time, the site was manifested by a lithic artifact scatter across the bladed area. Material recovered included chert tools, flakes, and core fragments, but no artifacts diagnostic of the period of occupation (Kreisa and Walz 1997:101).

The PSAP traditional assessment (Figure 4) began with a controlled surface collection of 3,200 m^2 (.53 of the total site area). Each of the eight 20 x 20 m grid units established for the geophysical survey was subdivided into four 10 x 10 squares. Surface visibility was nearly 100%, and all artifacts observed were collected in each square. A total of 233 artifacts was recovered from the 32 squares, with an average of 7.25 items per square. Artifacts were found to be most abundant in

a roughly oval-shaped, 30 x 30 m area.

The traditional assessment also included the excavation of shovel tests and test units (Table 3). Fourteen shovel tests were excavated, exposing an area of approximately 2.84 m^2. This was followed by the excavation of four 2 x 1 m test units that exposed an additional 8 m^2, bringing the total area excavated to 10.84 m^2. This represents about .0018 of the site as a whole (Kreisa and Walz 1997:103).

The shovel tests and test units indicated the extent to which the site had been damaged by the removal of topsoil. Around the site margins, the A horizon was generally 10 to 20 cm thick, and up to 35 cm thick in some areas (TU 3). Within the bladed area, however, only 5 to 10 cm of the A horizon remained. Artifact density was low, and with very few exceptions, artifacts were restricted to the A horizon. Surprisingly, the modest artifact concentration identified in the controlled surface collection corresponded to the area where much of the A horizon had been removed (Kreisa and Walz 1997:106).

The traditional assessment recovered a total of 262 artifacts, all lithic items. Most (89.3%) of these were from the controlled surface collections. The four test units produced only 28 items. The recovered assemblage is comprised primarily chipping debris, including cores; primary, secondary, tertiary, and broken flakes; shatter; and a small number of biface fragments. This small lithic assemblage suggests that the full range of chert reduction, tool manufacturing, and maintenance activities were conducted at the site. None of the recovered artifacts was assignable to a particular time interval or culture-historical unit (Kreisa and Walz 1997:106-107).

The traditional assessment indicated that site 14RY5155 is not eligible for the National Register. The PSAP investigations revealed no evidence for the presence of discrete subsurface features such as pits or hearths. Intact deposits were present in the form of an unplowed A horizon with some artifact contents. However, these deposits had already been severely impacted by the mechanized stripping. Furthermore, artifact density in the remaining deposits was light. No temporally diagnostic artifacts or carbon specimens adequate for radiocarbon dating were recovered, and there is little reason to think that additional work at the site would result in the recovery of such materials. Without reliable chronological information, other data from the site cannot be used to address important research questions. On balance, 14RY5155 is not eligible for the National Register because of a lack of chronological information and the effects of previous impacts to the cultural deposits (Kreisa and Walz 1997:110-111).

14GE3108

The Station Agent site (14GE3108) is located near the extreme southern boundary of Ft. Riley, within a heavily developed portion of the cantonment (Kreisa and Walz 1997:111). The site includes the archaeological remains of a structure occupied or otherwise used by the individual who managed the railroad station located immediately east of the site. The Station Agent site is situated

on a level terrace near the Kansas River. Present ground cover is low (regularly mowed) grass with a number of mature oak trees. The western portion of the site has been extensively disturbed by the installation of utility poles, buried cables and/or pipes, and localized blading. Portions of concrete foundations, brick sidewalks, depressions, and localized differences in vegetation indicated the presence of historic features at the site.

Soils at 14GE3108 are mapped as Eudora silt loam, 0-1% slope (Jantz et al. 1975). Included in the Smolan-Geary soil association, Eudora soils consist of deep, nearly level silt loams formed in alluvium. In a typical Eudora soil profile the A horizon consists of a grayish-brown (10YR5/2) silt loam extending to 25 cm bs. Below this, an AC horizon comprised of grayish-brown and light grayish-brown (10YR6/2) silt loam extends to 46 cm bs. The C horizon extends from 46 to 91 cm bs and consists of a very pale brown (10YR7/3) very fine sandy loam. Archaeological investigations conducted at the Station Agent site subsequent to the geophysical survey did not identify an AC horizon. Otherwise, the Station Agent site soil profile is similar to that described here (Kreisa and Walz 1996:110).

A preliminary walkover of the Station Agent site revealed several surface features and indications of subsurface features. A plan map of the site (Figure 5) prepared by PSAP (Kreisa and Walz 1997:113) shows 9 depressions (4 of them large enough to suggest architectural remains), 2 cement pads, 3 sidewalks, and 1 wall foundation.

The traditional assessment of the Station Agent site included the excavation of 10 shovel tests that exposed an area of 2.03 m^2 and four 2 x 1 m test units that exposed an additional 8 m^2 (Table 3). The total area excavated was approximately 10 m^2, representing .0017 of the overall site. The ten shovel tests were evenly distributed across the site (one in the center of each 20 x 20 m block). Seven of the tests were positive, recovering a total of 70 historic artifacts. Most of the shovel tests encountered two soil strata, but the color and texture characteristics of the profiles were highly variable. This variability in soil across the site was attributed to the intense and extensive nature of historic use of the site (Kreisa and Walz 1997:114).

Two of the shovel tests and all four of the test units identified cultural deposits. A shovel probe located at N510 E450 encountered a concrete slab whereas the probe at N510 E490 documented a 4 cm thick layer of coal and cinders. Test Unit 1 was positioned so as to investigate a concrete foundation visible on the surface. This foundation and wall complex was designated as Feature 1. Units 2 and 3 were located within slight depressions; (these are not among the 9 depressions shown on the site plan map). Feature 2 (in TU 2) was recorded as a concrete slab with an embedded metal pipe. The slab was 120 cm wide, 20 cm thick, and indeterminate in length. The impressions of bricks in the concrete suggested that the slab may have been a section of flooring. Test Unit 3 encountered relatively complex stratigraphy which included a layer of gravel interpreted as a path or pad adjacent to a structure. Unit 4 was positioned so as to examine the northeastern portion of the site, in an area where there was no surface indication of a subsurface feature. This unit documented a sequence of four strata including two interpreted as historic middens (Kreisa and Walz

1997:114-117).

The recovered artifact assemblage included 3,310 items. Most (94%) of these were recovered in the test units. Bottle glass dominates the test unit assemblage (1,187), followed by unidentified metal (556), coal (487), flat glass (138), and concrete (100). Other relatively abundant categories included bone and shell (96), brick (91), machine-made nails (69), wire nails (68), and gravel (60) (Kreisa and Walz 1997:126-127). Overall, the artifacts recovered at 14GE3108 suggest a commercial rather than a domestic occupation. There is little evidence of military activity at the site. The artifacts suggest that much of the occupation post-dates 1920. Evidence for this includes the types of bottle manufacturing techniques present, as well as the absence of manganese glass, which was common between 1880 and 1918. Evidence for a pre-1920 occupation is present, however, including the predominance of machine-made nails in TU 4 (Kreisa and Walz 1997:119-128).

The traditional assessment of the Station Agent site did not result in a final determination of the site's eligibility for the National Register. The site clearly did meet two important criteria. First, the artifacts recovered at the site provided some chronological information, and there is good reason to assume that additional work at the site would recover many other temporal diagnostics. Second, intact deposits (including architectural remains and midden) were identified at the site. However, the absence of a documents search (which was not required by the Scope of Work) and site-specific historic context limited the potential for assessing the site's relevance to important research issues. Two research questions to which the Station Agent site was deemed to be potentially relevant were the nature of civilian-military interaction and the impact of major events (including World War I). Without more historical information about the site, it is difficult to determine whether the artifacts and features present there are informative about these (and other) research issues. Consequently, Kresia and Walz (1997:128-130) recommended that a documents search and possibly an oral history be conducted prior to a formal determination of eligibility.

14RY193

The Thomas R. Hair site (14RY193) is located in the extreme northern portion of Ft. Riley, 2 km south of the town of Riley (Figure 1). Situated on an upland ridgetop, the site measures 150 by 150 m. The core area of the site is bounded on the north and west by a remnant hedgerow of trees. An abandoned section road passes through the southern portion of the core area. A number of architectural features were visible on the surface, including several concrete pads, a cistern, and a cellar (Halpin 1997:55-56). Earlier documentation of the site (Halpin and Babson 1997) noted that the site had been disturbed by vehicle traffic and possible bulldozing, but that there was still a good potential for subsurface integrity (Halpin 1997:55-65).

A pedestrian survey of the site conducted as an initial step in the 1996 traditional assessment fieldwork revealed ten features: 3 concrete slabs/pads, 3 possible cellar depressions (1 likely to be a military excavation), 2 wells, 1 cistern, and 1 pipe associated with the cistern (Figure 6). Excavations at the site included 113 posthole tests distributed at 5 m intervals throughout the core

area of the site, and four 1 x 2 m test units (Table 3). The postholes, which each measured approximately .15 by .15 m, exposed a total area of 2.54 m^2. The four test units exposed an additional 8 m^2, bringing the total area excavated to about 10.5 m^2. This sample represents .00047 of the site as a whole, and a somewhat larger portion of the site's core area (Halpin 1997:60-63).

The 27 positive posthole tests yielded 91 artifacts recovered from depths ranging from 5 to 30 cm bs. No discrete subsurface features were identified by the posthole tests. One feature, the corner of a coursed limestone foundation, was identified in one of the test units (TU 2). This foundation, believed to represent the house, was associated with a depression designated Feature 7. No features were identified in the other three test units (Halpin 1997:63).

A total of 562 artifacts was collected during the traditional assessment. Most of these materials date from the late 19th to mid-20th centuries. Many of the artifacts were small, and the most recent items were found in all excavation levels. The most commonly occurring categories were wire drawn nails (75), machine cut nails (64), clear and light green curved glass (54), flat glass (51), undecorated whiteware (44), and undecorated ironstone (30) (Halpin 1997:66-69).

The traditional assessment demonstrated that vehicular traffic and possibly bulldozing has seriously damaged the Hair site. The bulldozing was presumably associated with efforts to salvage or raze the standing buildings when the military acquired the property about 1966. Deep vehicle ruts are the result of military training. The presence of the most recent artifacts in all excavation levels indicates that the stratigraphy at the site has been destroyed. Because of the lack of intact deposits, the Hair site was determined to be ineligible for nomination to the National Register (Halpin 1997:71).

Nature and Results of the Ft. Riley Geophysical Assessments

Geophysical surveys were conducted at the same four sites that were investigated using the traditional assessment strategy (14RY3183, 14RY3193, 14RY5155, and 14GE3108). A less intensive resistivity survey was also conducted at the fifth, "extra" site (14RY193). At each site, the geophysical surveys were conducted within a series of 20 x 20 m grids. The grids were established by PSAP using an EDM prior to the geophysical work. Wood stakes were used to mark the corners of each grid unit. Within each 20 x 20 m grid, horizontal control was maintained using a number of plastic ropes marked at one meter intervals. The southwest corner of each grid was used as a datum. These techniques made it is possible to relocate a mapped feature to within a fraction of a meter.

All resistivity and magnetic data were processed using the Geoplot 2.1 software provided by the Geoscan instrument manufacturers. Overall, the data from the surveyed sites was of excellent quality, with relatively little need for sophisticated processing. The resistivity data were highpass filtered in order to enhance the visibility of small, low contrast features. The zero mean highpass filtered map can be thought of as a resistivity map containing all features with resistivity values that are greater than the local average resistivity, and all features with negative values that are less than

the average. Local average values are removed from the filtered maps. This kind of filtering allows one to produce maps showing only high resistivity values that are likely to correspond to stone architecture, sand and/or gravel filled pits, etc., or low resistivity values which may correspond to high moisture backfilled pits, trenches, etc. Most of the survey results were displayed using a series of black/white halftone maps. Data values were indicated based on relative lightness and darkness of the gray tones. In some maps, "red" color was used to convey relatively high and relatively low values. Other maps used green to highlight selected anomalies and/or to show the suggested locations of alignments of shovel tests.

Since the key results of the geophysical surveys are presented using maps, it is useful to explain the terms that appear in the map captions.

Resistivity Maps

"All Data" maps present all of the data collected, with no filtering or other processing.

"Highpass Filtered Data" maps present all of the data that remain after the average background values have been removed. Positive values are those greater than the local average, whereas negative values are lower than the average.

"Higher than Average Data" maps show only the high (relative to local average) resistivity values.

"Lower than Average Data" maps show only the low (relative to local average) resistivity values.

Magnetic Field Gradient Maps

"All Data" maps for the magnetic surveys are (unless specified otherwise) plots of all collected magnetic data.

"All Data After Iron Removal" maps show all magnetic data after the removal of large magnitude values associated with iron objects. This removal enhances the potential for detecting weak magnetic values likely to represent prehistoric features such as hearths.

"All Low Level Magnetic Data" maps show the magnetic data that remain after the removal of strong magnetic values.

"Iron Features Map" show all strong magnetic features.

"Negative Magnetic Data-Disturbed Soils" maps show all low level negative data that can be associated with soil disturbances.

"Positive Magnetic Data-Disturbed Soils" maps show all low level positive data that can be related to soil disturbances.

14RY3183

In preparation for the geophysical survey at 14RY3183, PSAP established a grid comprised of 8 contiguous and 1 detached 20 x 20 m blocks. Roughly 50% of the gridded area was in the dense, second growth forest that covered the site margins. The remainder of the gridded area was in an open, level area of low (15-30 cm) grass. In an effort to avoid areas that had been impacted by bulldozing, it was subsequently decided to extend the grid an additional 20 m to the north, and to survey the four northmost blocks. Thus, much of the surveyed area was within the wooded portion of the site. The grid was also extended to the east (into the grassy area) to include a partial block (15 m E-W by 20 m N-S). The purpose of this partial block was to investigate an area where a suspected prehistoric structure had been identified in the 1995 test excavations (Richardson 1997). On balance, the resistance and magnetic surveys at 14RY3183 each covered a total area of 1,750 m^2 (Table 4).

Results of both the resistivity and magnetic surveys at 14RY3183 were disappointing. Linear patterns in the resistivity maps reflect the result of bulldozing, whereas the amorphous areas of relatively high and low resistivity probably reflect disturbances from (current and old) tree roots and other bioturbations. The bulldozing was associated with construction of the access road that bisects the site. Small piles of backdirt remain just inside the treeline, particularly on the northwest side of the road.

It was expected that pit features at 14RY3183 would be characterized by relatively low resistivity, given that their fill would have a higher organic content than the surrounding matrix. Such anomalies should stand out on a map of the High Pass Filtered Negative Data Only data. Unfortunately, all anomalies shown there appear to reflect local geology or recent earth moving. A small number of low resistivity and high resistivity anomalies that could conceivably represent pits are indicated on the High Pass Filtered Data map (Figure 7) (Somers 1997:17). These were selected for ground truthing because they were as likely to correspond to cultural features as any of the other anomalies (Table 5). None were viewed, however, as likely candidates to be prehistoric pits.

The maps resulting from the magnetic survey at 14RY3183 also indicate a highly disturbed site. The ubiquity of historic and/or recent metal objects at the site seriously limited the effectiveness of the magnetic survey. The effect of removing high values associated with metal objects can be seen in the large blank areas in Figure 8 (All Data After Iron Removal). Even after removing these very high values, the magnetic data still have a standard deviation of about 3nT. An undisturbed site would be expected to have a standard deviation on the order of 1 nT. Prehistoric hearths at the site were expected to be manifested as relatively weak positive anomalies. The uniform background of an undisturbed site would greatly enhance the potential for discerning such subtle anomalies. At 14RY3183, however, the signal to noise ratio was simply too low to allow much opportunity to

identify hearth features. Somers did select several localized weak magnetic anomalies for ground truthing (Table 5), but they were viewed as unlikely candidates to represent cultural features (Somers 1997:16).

PSAP excavated shovel tests to investigate 7 of the anomalies selected for ground truthing (Table 6). The limited amount of ground truthing at 14RY3183 reflected the assessment that the anomalies were unlikely to represent cultural features. There were no clear geophysical or archaeological reasons to investigate any particular anomalies, so the selection was based largely on the ease with which the anomalies could be located using tapes stretched through the rather dense undergrowth.

The anomaly shovel tests were approximately .45 x .45 m in plan and at least .6 m deep. Each of the tests encountered three soil horizons. The A horizon was generally 30 to 35 cm thick, below which was a 20 to 30 cm thick E horizon. The lowermost 10 cm or so of each test was within the B horizon. None of the seven anomaly tests encountered any evidence for prehistoric pits or other features. The anomaly tests were characterized by relatively low densities of artifacts. Whereas the units excavated in the traditional assessment produced approximately 493 items per m^3, the anomaly tests produced only 105 artifacts per m^3.

Particularly disappointing was the geophysical survey's failure to provide any clear evidence for the presence of the daub and rock concentrations that were, in subsequent excavations (Richardson et al. 1997), determined to be the remains of a Smoky Hill Variant structure and hearth complex. The daub should have been associated with a weak positive magnetic anomaly, much like that of a hearth only quite a bit larger. Unfortunately, the structure was located in a portion of the survey area that was characterized by recent or historic metal items. The removal of the high values associated with the recent metal essentially "blanked out" the area of the structure.

The resistivity survey also failed to identify the Smoky Hill structure. Anomaly Test 5 was located within a meter or so of the rock concentration/hearth identified in subsequent excavations (Richardson et al. 1997). That anomaly test did recover substantially more artifacts than the other anomaly tests (n=33, 122.6 g), but most of the weight (92.2 g) of this material represents a single chert core, not the limestone slabs that characterize the rock concentration /hearth (Kreisa and Walz 1997:73, 167). On balance, the resistivity survey provided no indications of the presence of the structure and hearth complex. It is relevant to note that subsequent excavations in the structure area revealed no other concentrations of daub, pits, or basin associated with the structure and hearth complex.

14RY3193

In preparation for the geophysical survey at the Army City site (14RY3193), PSAP established a site grid comprised of 24 20 x 20 m blocks. Twelve of these blocks were located west of Fourth Street and the remainder were located to the east. It was later determined to focus the

geophysical survey in the area west of the road. During the course of the survey, 5 additional 20 x 20 m blocks were defined there, with the result that the grid was extended 20 m to the south and 20 m to the west. A magnetic survey was conducted in 14 blocks whereas the resistance survey was restricted to 9 blocks. The limits of the two surveys were not coterminous but did overlap in 6 blocks (Figure 3; Table 4).

Prior to the survey, Somers determined (based on uncalibrated field measurements) that the magnetic susceptibility of the soils at Army City was moderately high. As such, the site offered good potential for mapping both historic and prehistoric soil disturbances. Features such as back-filled historic pits, footings, foundations, and roads were all expected to be discernable in a magnetic survey. Soil resistivity was found to be about 50 Ohm-meters (Somers 1997:21).

Both the resistivity and the magnetic surveys at Army City were highly productive. The All Data and Highpass Filtered (Figure 9) maps both show numerous linear and rectangular resistivity anomalies that are strongly suggestive of historic architectural remains. Prior to ground truthing, the high resistivity anomalies were predicted to correspond to deposits of stone, cement, rubble, gravel, and/or sands, whereas the low resistivity anomalies were thought to represent soils that were clayey, moist, and/or disturbed (Somers 1997:33).

To better understand the anomalies, the high pass filtered data were separated into two maps, one showing Lower Than Average (Negative) Data values, and the other showing Greater Than Average (Positive) Data values (Figures 10 and 11, respectively). In the Lower Than Average map, many of the most distinct anomalies are long, narrow, and aligned in rectangular patterns suggestive of the remains of walls, footings, utility trenches, etc. In contrast, the Greater Than Average anomalies tend to be amorphous but wider relative to their length. In many cases, Greater Than Average anomalies appear to be circumscribed by the low resistivity anomalies. The higher resistivity anomalies were interpreted as possible room fill.

The results of the magnetic survey at Army City were plotted in several formats. Figure 12 shows large magnitude magnetic values associated with in situ iron objects. One can detect in this map two approximately perpendicular alignments (NW-SE and NE-SW) suggestive of architectural remains. Figure 13 presents all of the magnetic data with the exception of the very strong values. In this map, as well as in the Positive Magnetic Data (Disturbed Soils) (Figure 14) and Negative Magnetic Data (Disturbed Soils) maps one can easily see linear patterning suggestive of historic architectural remains. Lines added to the disturbed soil maps show NW-SE alignments with two similar but nevertheless different orientations. Somers suggested that this could indicate two archaeological components. Possibly one alignment conforms to the overall town plan (i.e., the orientation of Army City buildings and streets), whereas the other alignment reflects the post occupational demolition period. For example, one of the alignments of disturbed soil could result from the repeated movement of bulldozers or trucks (Somers 1997:33-34).

Somers recommended ground truthing excavations of 51 anomalies; (25 resistivity and 26

magnetic anomalies) (Table 7). Many additional anomalies appeared in the various geophysical maps, but those selected comprised a fairly representative sample. As the SOW required PSAP to test a total of 60 anomalies among the four sites, it was decided to investigate 43 of the Army City anomalies. The ground truthing shovel tests measured approximately .45 by .45 m (some were smaller) and ranged from .35 to .8 m deep. All excavated soil was screened through .25 inch mesh and artifacts were saved for analysis.

If the geophysical anomalies were associated with cultural activity, it was expected that the anomaly tests would encounter disturbed soil profiles, concentrations of artifacts, and/or in situ features. Kreisa and Walz (1997:91) found that 25 of the 43 anomaly tests exhibited normal A-AB or A-AB-B soil profiles (Table 8). These tests produced an average of 6.6 artifacts each. Deleting three of these tests that produced relatively high artifact counts reduced the mean of the remaining tests to 2.0 artifacts per test. In contrast, the 17 anomaly tests that exhibited disturbed soil profiles produced an average of 15.2 artifacts each. Finally, the one anomaly test that encountered a definite feature (discussed below) produced 128 artifacts.

Kreisa and Walz (1997:91) also compared the density of artifacts in the disturbed-profile anomaly tests with that of the normal-profile anomaly tests and the other (traditional assessment) excavation units. The four test units and the 25 normal profile anomaly tests each involved the excavation of about 2.5 m^3 of soil, and each technique (test units and anomaly tests) yielded about 66 artifacts per m^3. In contrast, the 17 anomaly tests with disturbed profiles involved the excavation of about 1.9 m^3 of soil and yielded 136 items per m^3. On balance, the anomaly tests with disturbed profiles produced about twice as many artifacts as did all other excavations at the site. Kreisa and Walz (1997:91) suggested from this that "the anomaly tests in which disturbed profiles are present probably represent some type of historic disturbance or feature, although the type of feature...is unknown at present."

Additional evidence that many of the anomaly tests encountered features or areas of cultural disturbance can be gleaned from a closer examination of the types of anomalies examined. Twenty-four of the anomaly tests were targeted on resistance anomalies (Table 7). Forty-seven percent (7 of 15) of the tests targeted on low resistance anomalies exhibited a disturbed soil profile. In all cases, evidence for the disturbance was very subtle, comprised of modest soil mottling. Mottling can result from an eluviation of clays or from the soil being wet for extended periods. At Army City, however, the correlation of mottling with a relative abundance of artifacts suggests that the mottling is the result of cultural activity.

Seventy-eight percent of the nine probes targeted on high resistance anomalies encountered disturbed soil profiles. Here again, evidence for disturbance was very subtle. Only one of the anomaly tests encountered a definite archaeological feature. This was a concrete slab or floor located approximately 65 cm below surface in anomaly test 7. Based on the resistivity map (Figure 11), this slab measured about 5 m in diameter.

Evidence that many of the anomaly tests encountered cultural deposits is also provided by relative differences in the abundance of artifacts. Coal and cinders make up about 53% of the artifacts recovered at Army City. Architectural materials such as concrete fragments, gravel, nails, and flat glass make up most of the remainder. The 12 shovel probes excavated by PSAP as part of the traditional site assessment, (and which were not targeted on geophysical anomalies), produced only three artifacts. The nineteen anomaly tests targeted on the magnetic anomalies produced an average of 1.3 artifacts per probe. In contrast, the 24 anomaly tests targeted on resistance anomalies produced 528 items, with a mean of 22 artifacts per probe. The resistance anomalies clearly represent areas of disturbed soil characterized by a relative abundance (but in absolute terms, a modest amount) of artifacts.

14RY5155

In preparation for the geophysical survey at 14RY5155, PSAP established a grid at the site consisting of 8 contiguous 20 x 20 m blocks. These blocks were located within the stripped, central portion of the site. The magnetic survey included all 8 of the blocks whereas the resistance survey included only four of the blocks (Figure 4). Prior to the geophysical fieldwork, Somers determined that the magnetic susceptibility of the near surface soils was moderately high and thus conducive to the detection of hearth features.

The resistivity and magnetic maps of 14RY5155 produced no evidence of subsurface cultural deposits. The All Data resistivity map shows no anomalies suggestive of cultural activity. In the High Pass Filtered Data map (Figure 15) one can see a large number of small, dark, high resistivity anomalies. All of these appear to be the result of soil disturbances associated with recent bulldozing. In an effort to discern evidence of pit features, which were expected to be manifested as low resistivity anomalies, all the lower than average values were plotted on the Negative Data Only map. This map shows no discrete low resistivity anomalies with a size and configuration suggestive of prehistoric or historic pits (Somers 1997:49)

The magnetic survey resulted in an excellent data set, but one that shows no indications of cultural deposits. The All Data map (Figure 16) shows numerous parallel alignments of positive values, as well as a number of amorphous negative magnetic anomalies. The linear patterning is again the result of the recent bulldozing. A systematic walkover of the site following the magnetic survey indicated that the other magnetic anomalies relate to micro-topographic variation, i.e., the subtle ridges and swales created by the bulldozer (Somers 1997:49). On balance, no geophysical anomalies warranting ground truthing were identified.

14GE3108

To facilitate a geophysical survey at the Station Agent site (14GE3108), PSAP archaeologists established a grid comprised of 10 contiguous 20 x 20 m blocks. The resistance survey covered the entire grid whereas the magnetic survey included only the five blocks along the southeast side of the

grid (Figure 5, Table 4).

The High Pass Filtered resistivity data map (Figure 17) exhibits a number of pronounced anomalies suggestive of historic architecture. High resistivity (dark shaded) anomalies were predicted to correspond to stone, gravel concentrations, or rubble fill, whereas low resistivity anomalies were thought to be areas of fine grained (clay and top soil) and/or moist soils. The high resistivity and low resistivity anomalies appear most clearly when plotted separately in the Greater Than Average Data and Less Than Average Data maps (Figures 18 and 19, respectively). Several of the larger anomalies include areas of lower and higher resistivity. This heterogeneity suggests internal variability in depth, structure, materials, and/or content (Somers 1997:61).

The magnetic survey of the Station Agent site identified a number of anomalies, most of which represent iron objects. Individual items and scatters of multiple items appear on the All (Magnetic) Data map presented as Figure 20.

Somers recommended ground truthing excavations for 13 resistivity and 9 magnetic anomalies (Table 9). Because many anomalies had been investigated at the other sites (particularly Army City), however, it was only possible to ground truth 10 of the Station Agent anomalies (Table 10). The four magnetic anomalies chosen for ground truthing were predicted (by Somers) to correspond to a pipe, a pipe/drain/ditch, a cluster of iron objects, and a road/path/or bulldozer tailings. Kreisa and Walz (1997:119) reported that none of these anomaly tests encountered a feature. These shovel tests recovered from 0 (in A1, targeted on the pipe/drain/ditch) to 25 (in A4, the road/path/bulldozer tailings) artifacts. The shovel test used to investigate anomaly A2, the iron cluster, encountered a modest concentration (16, 30.2 g) of cinders (Kreisa and Walz 1997:119).

The remaining six tests were all targeted on resistivity anomalies. These shovel tests investigated large, high resistivity anomalies interpreted as stone/cement/or gravel (tests S1, S2, S5, and S6) or, in the case of S3 and S4, a large pit filled with stone or cement. The 6 anomaly tests represent 3 pairs. In each pair, one of the anomaly tests was positioned so as to be within the anomaly whereas the other test was located outside of the suspected feature.

Anomaly test S1 was located within a large (5 x 10 m), internally heterogeneous high resistivity anomaly centered at approximately N4 E72 (Figure 17). This test encountered a "dense gravel layer/walkway" at 20 cm bs (Kresia and Walz 1997:119). The anomaly test located outside of the anomaly located a coal cinder zone, but this was not interpreted as a structural feature. Kreisa and Walz (1997:118-119) reported that S1 had encountered a walkway. However, the overall size and rectangular shape of the anomaly in question suggests that it may represent some other type of feature.

Anomaly tests S3 and S4 were excavated to investigate a large and roughly square (12 x 15 m), internally heterogeneous (including both lower and higher than average resistivity components) anomaly centered at approximately N8 E38 (Figure 17). Anomaly test S3 was intended to be located

outside of this anomaly but was, in fact, located within a lower than average resistivity portion of it. This test recovered relatively abundant artifacts (n=27, 238.5 g), including a number of pieces of bottle glass, but did not encounter a structural feature. Test S4, intended to be located within the anomaly, was in fact located within a long and narrow (10 x 1.5 m) high resistivity portion of the overall anomaly. This shovel test encountered a concrete slab at 15 cm bs. The slab was interpreted in the field as a possible floor, but the elongate shape of the high resistivity portion of the anomaly suggests that the slab may be a large displaced section of floor material. On balance, the artifacts and building materials recovered in tests S3 and S4 were compatible with Somer's interpretation of the anomaly as a cement filled pit.

Anomaly tests S5 and S6 investigated a large, L-shaped, internally heterogeneous (high and very high resistivity values) anomaly centered at approximately N16 E44 (Figure 17). The shovel test (S5) located outside of this anomaly recovered no artifacts and no evidence of structural features. Test S6, located within the anomaly, recovered several relatively large pieces of concrete and one piece of slag (3, 422 g), but also revealed no indication of a structural feature. These findings do not appear to negate Somer's interpretation of this anomaly as a concentration of stone, cement, or gravel. It would appear, however, that this anomaly, or at least the portion of it investigated by S6, does not represent an intact structural feature such as a building foundation or floor. The anomaly may, however, represent a concentration of building debris.

14RY193

The Thomas R. Hair site (14RY3108) was not officially included in the cost benefit study. The Hair site served as an alternate, to be included in the study only if one of the other sites became unavailable due to military training activities. A grid comprised of 25 20 x 20 m blocks (10,000 m^2) was established, but the site did not become one of the four primary project sites. Ft. Riley made plans to include the Hair site in a later, separately funded project. As a professional courtesy to Ft. Riley, Somers conducted an abbreviated resistivity survey at the Hair site following completion of the work called for by the cost benefit project's SOW. A draft resistivity map was produced, but no detailed analysis was conducted, and no list of anomalies suitable for ground truthing was prepared. At the other sites, two resistivity readings were taken per m^2. The resistivity survey at the Hair site was abbreviated in that only one reading per m^2 was recorded, and the survey included only 8 blocks (3,200 m^2). Note that the east edge of the survey area is comprised of two half-blocks, each measuring 20 m north-south by 10 m east-west.

A comparison of Figures 6 and 21 suggests that a number of the features identified during the traditional assessment (Halpin 1997) are also visible on the resistivity map. Several other features are either not easily discernable on the resistivity map (Feature 4), or are only discernable as very amorphous anomalous areas (Feature 2). However, several distinct and relatively rectangular positive anomalies are present just east of the area investigated by shovel tests. These anomalies (which appear as black areas on Figure 21) could conceivably represent unidentified features, although there is presently no evidence to support this. It is also possible that these anomalies represent disturbed areas

dating to the razing of the site after it was purchased by the Army in 1966.

Table 2: Time and Cost Data for Traditional and Geophysical Site Assessments

TASK	14RY3183	14RY3193	14RY5155	14GE3108	14RY193
Surface Collection (hrs)	0.00	0.00	12.00	0.00	n.a. [a]
Shovel Tests (hrs)	8.00	3.50	7.00	5.00	n.a.
Site Plan Mapping (hrs)	9.50	5.00	6.00	10.50	n.a.
Test Unit Excavation (hrs)	164.00	71.00	55.50	77.50	n.a.
Artifact Processing (hrs)	29.00	11.50	6.50	37.50	n.a.
Artifact Analysis (hrs)	39.50	12.00	19.50	35.00	n.a.
Total: Traditional Excavation (hrs)	250.00	103.00	106.50	165.50	100 [b]
Anomaly Test Excavation (hrs)	15.50	35.50	0.00	14.50	0
Anomaly Test: Artifact Process & Analysis	2.45	18.02	0.00	2.69	0
Total: Anomaly Test (hrs)	17.95	53.52	0.00	17.19	0
Anomaly Test: % of Total Hours at Site (%)	0.07	0.39	0.00	0.10	0
Total: Traditional & Anomaly Test (hrs)	265.50	138.50	106.50	180.00	100
Total: all Sites (hrs) [(c)]	690.50	690.50	690.50	690.50	n.a.
Percent Total Hours Each Site (%)	0.38	0.20	0.15	0.26	n.a.
Project Cost (Total: all Sites) ($)	59465.00	59465.00	59465.00	59465.00	n.a.
Total Cost Each Site ($)	22864.53	11927.45	9171.65	15501.38	11250.34 [d]
Anomaly Test Cost ($) Each Site	1545.83	4609.08	0.00	1480.38	0
Traditional Cost ($) Each Site	21318.70	7318.37	9171.65	14020.99	11250.34 [d]

Notes:
(a) n.a. = Data not available or not applicable
(b) Data reported by Halpin (1997:166), not estimated
(c) Does not include 100 hrs at 14RY193
(d) Cost estimated based on percentage of total project time and total project cost
(Values have been rounded for display)

Table 3: Traditional Assessment Level of Effort and Results.

	14RY3183	14RY3193	14RY5155	14GE3108	14RY193
Site Area (m^2)	45,000	6,400 [a]	6,000	6,000	22,500
Percentage of Site Excavated	<1	<1	<1	<1	<1
Control. Surface Collect. (m^2)	0	0	3,200	0	0
Shovel Tests (n)	14	12	14	10	113
Positive Shovel Tests (n)	5	3	0	7	27
Artifacts from Posthole Tests (n)	144	3	0	70	91
Test Units (n)	6	4	4	4	4
Test Unit Area (m^2)	11	8	8	8	8
Artifacts from Test Units (n)	3,105	164	28	3,113	471
Features on Surface (n)	0	0	0	15 [c]	10 [e]
Features in Units (n)	0	0	0	2 [d]	1 [f]
Midden Present?	Yes	No	No	Yes	No
Intact Stratigraphy?	Yes	Yes	Yes [b]	Yes	No
Eligible for NRHP?	Yes	?	No	?	No

Notes:
(a) Refers to portion investigated; total site area is ca. 16 ha
(b) Most artifacts were recovered in A-horizon, which has been partially truncated;
(c) Kreisa and Walz (1997:113 Figure 19) show but do not number 15 possible features: 9 depressions, 2 cement pads, 3 sidewalks, 1 wall foundation.
(d) Kreisa and Walz (1997: 114-117) number 2 features but other feature-like deposits also described.
(e) Halpin (1997:60-61) numbers 10 features: 3 concrete slabs, 3 cellars, 2 wells, 1 cistern, 1 pipe.
(f) Halpin (1997:63) describes a limestone foundation but does not number it as a feature.

Table 4: Geophysical Assessment Level of Effort, Results, and Costs Per Site.

	14RY3183	14RY3193	14RY5155	14GE3108	14RY193	Total (n)
Resistance Grids (n)	5	9	4	10	8	36
Resist. Survey Area (m^2)	1,750	3,600	1,600	4,000	3,200	14,150
Magnetic Grids (n)	5	14	8	5	0	32
Magnetic Survey Area (m^2)	1,750	5,600	3,200	2,000	0	12,550
Total Grids (n)	10	23	12	15	8	68
Total Survey Area (m^2) [a]	1,750	6,800	3,200	4,000	3,200	18,950
Percentage of Site Surveyed	3.90	4.30	53.30	66.67	14.22	7.91
Anomaly Shovel Tests (n)	7	43	0	10	0	60
Positive Anomaly Tests (n)[b]	0	18 [c]	0	3 [d]	0	21
Artifacts from Anomaly Tests	111	551	0	121	0	783
Geo. Survey Cost ($)	4,521.74	7,304.35	4,173.91	5,217.39	2,782.61	24,000
Anomaly Test. Cost ($)	1,545.83	4,609.08	0	1,480.38	0	7,635.29
Total Geo. Cost ($)	6067.57	11913.43	4173.91	6697.77	2782.61	31,635.29

Notes:
(a) Resistance and magnetic survey areas overlap
(b) Positive anomaly shovel tests identified features or feature-like deposits
(c) Kreisa and Walz (1997:93) report 1 feature and 17 possible features
(d) Kreisa and Walz (1997:119) report 2 structural features and one cinder layer

Table 5: Description of Geophysical Anomalies at ForThree Site (14RY3183). (After Somers 1997b:17-18).

GEO	PSAP	North	East	Type	Value	Description	Interpretation	Test. Result [b]
C	1	21.50	37.00	R	Low	Localized	None possible	Non-Cultural
D	2	19.50	34.00	R	Low	Localized	None possible	Non-Cultural
E	3	16.00	34.00	R	High	Localized	None possible	Non-Cultural
F	4	14.50	30.80	R	High	Localized [b]	None possible	Non-Cultural
B	5	19.25	41.50	R	Low	Localized	None possible	Non-Cultural
BB	6	26.50	42.50	M	Weak	Localized	None possible	Non-Cultural
EE	7	8.00	2.00	M	Weak	Localized	None possible	Non-Cultural
A	(a)	21.00	41.00	R		1996 test unit		(a)
G	(a)	11.50	31.00	R	High	Localized	None possible	(a)
H	(a)	12.50	43.50	R	High	Localized	None possible	(a)
AA	(a)	21.00	41.00	M		1996 test unit		(a)
CC	(a)	29.50	13.50	M	Weak	Localized	None possible	(a)
DD	(a)	15.00	10.50	M	Weak	Localized	None possible	(a)

Notes:
GEO = Letter designating anomaly assigned by geophysicist
PSAP = Number designating anomaly assigned by archaeologist
Grid North and Grid East = Grid coordinates used by geophysicist
Type R = Resistance anomaly, M = Magnetic anomaly
Value = Relative magnitude of R or M value
Description = General characteristics of anomaly
Interpretation = Cultural interpretation of anomaly by geophysicist prior to ground truthing
Test. Results = Results of ground truthing by archaeologist
(a) = no ground truthing

Table 6: Results of Anomaly Tests at ForThree Site (14RY3183) (From Kreisa and Walz 1997:73 Table 1).

Test	Target	Artifact Count	Artifact Weight	Comment
1	Pit	31	48.1	No feature identified-typical soil profile
2	Pit	2	1.9	No feature identified-typical soil profile
3	Pit	22	18.1	No feature identified-typical soil profile
4	Pit	21	53.1	No feature identified-typical soil profile
5	Pit	33	122.6	No feature identified-typical soil profile
6	Hearth	1	9	No feature identified-typical soil profile
7	Hearth	1	1.3	No feature identified-typical soil profile

Table 7: Description of Geophysical Anomalies at Army City (14RY3193). (After Somers 1997b:36-39).

GEO	PSAP	North	East	Type	Value	Description	Interpretation	Test. Result [b]
A	1	4.00	29.00	R	High	Amorphous Area	Wall	Poss Feature
B	2	5.50	26.00	R	Low	Discrete Area	Building	Poss Feature
C	3	10.00	22.00	R	High	Amorphous Area	Wall	Poss Feature
D	4	13.50	18.50	R	Low	Discrete Area in Linear Anomaly	Building	Poss Feature
E	5	27.00	24.50	R	Low	Linear Anomaly	Assoc. with Edge of Foundation	Non-Cultural
F	6	30.00	27.50	R	High	Discrete Amorphous Area	Building Foundation	Poss Feature
G	7	31.00	13.00	R	High	Localized	Stone, Cement, or Gravel Filled Pit	Feature
H	8	53.00	12.00	R	Low	Localized	Earth Filled Pit or Undisturbed Area	Non-Cultural
I	9	41.00	7.00	R	Low	Long, Linear	Footings, Walkways, or Ditches	Poss Feature
J	10	43.00	10.00	R	High	Long, Linear	Footings, Walkways, or Ditches	Poss Feature
K	11	44.50	11.50	R	High	Long, Linear	Footings, Walkways, or Ditches	Poss Feature
L	12	45.50	12.30	R	High	Long, Linear	Footings, Walkways, or Ditches	Poss Feature
M	13	48.50	14.00	R	Low	Long, Linear	Footings, Walkways, or Ditches	Non-Cultural
N	14	40.00	18.00	R	Low	Localized, Strong	Earth Filled or Undisturbed Area	Poss Feature
O	15	23.00	47.00	R	Low	Localized, Strong	Earth Filled or Undisturbed Area	Non-Cultural
P	16	35.50	20.00	R	Low	Localized, Strong	Earth Filled or Undisturbed Area	Poss Feature
Q	17	42.00	51.00	R	Low	Localized, Strong	Earth Filled or Undisturbed Area	Non-Cultural
R	18	46.00	52.50	R	High	Localized, Strong	Stone, Cement, or Gravel Filled Area	Non-Cultural
S	19	40.00	55.00	R	High	Localized, Strong	Stone, Cement, or Gravel Filled Area	Non-Cultural
T	20	38.00	24.00	R	High	Localized, Strong	Stone, Cement, or Gravel Filled Area	Non-Cultural
U	21	8.00	4.00	R	High	Localized, Strong	Stone, Cement, or Gravel Filled Area	Non-Cultural
V	22	7.50	13.00	R	Low	Localized, Strong	Earth Filled or Undisturbed Area	Poss Feature
W	23	43.00	19.00	R	Low	Localized, Strong	Earth Filled or Undisturbed Area	Poss Feature
X	24	50.00	34.50	R	Low	Localized, Strong	Earth Filled or Undisturbed Area	Non-Cultural
OO	25	45.00	35.50	M	Weak	Exceedingly Weak	Possible Back Filled Trench	Non-Cultural
NN	26	47.00	37.50	M	Weak	Exceedingly Weak	Possible Back Filled Trench	Non-Cultural
MM	27	48.50	39.00	M	Weak	Exceedingly Weak	Possible Back Filled Trench	Non-Cultural
PP	28	44.00	34.00	M	Weak	Exceedingly Weak	Possible Back Filled Trench	Poss Feature
LL	29	50.00	40.50	M	Weak	Exceedingly Weak	Possible Back Filled Trench	Non-Cultural
KK	30	52.00	38.00	M	Weak	Exceedingly Weak	Possible Back Filled Trench	Non-Cultural
JJ	31	55.00	36.00	M	Weak	Exceedingly Weak	Possible Back Filled Trench	Non-Cultural
QQ	32	59.00	28.50	M		Locus	Small Iron Object or Back Filled Pit	Non-Cultural
RR	33	100.00	37.00	M		Area	Large Number of Large Iron Items	Poss Feature
SS	34	115.00	57.00	M		Area	Large Number of Large Iron Items	Poss Feature
AA	35	-32.00	31.50	M		Not Sharp or Well Defined	Back-filled Trench	Non-Cultural
BB	36	-29.50	35.00	M		Not Sharp or Well Defined	Back-filled Trench	Non-Cultural

GEO	PSAP	North	East	Type	Value	Description	Interpretation	Test. Result [b]
CC	37	-28.00	37.00	M		Not Sharp or Well Defined	Back-filled Trench	Non-Cultural
DD	38	-25.00	39.50	M		Not Sharp or Well Defined	Back-filled Trench	Non-Cultural
EE	39	-14.00	46.00	M		Not Sharp or Well Defined	Back-filled Trench	Non-Cultural
FF	40	-11.50	49.00	M		Not Sharp or Well Defined	Back-filled Trench	Non-Cultural
GG	41	-8.00	53.00	M		Not Sharp or Well Defined	Back-filled Trench	Non-Cultural
HH	42	-4.00	57.00	M		Not Sharp or Well Defined	Back-filled Trench	Non-Cultural
II	43	36.00	5.00	M		Area	Large Number of Iron Objects	Poss Feature
Y	(a)	22.00	28.00	R	High	Localized, Strong	Stone, Cement, or Gravel Filled Area	(a)
TT	(a)	-40.00	58.00	M		Area	Large Number of Large Iron Items	(a)
UU	(a)	26.00	26.00	M		Area	Cluster of Iron Objects	(a)
VV	(a)	38.00	22.00	M		Area	Large Cluster of Iron Objects	(a)
WW	(a)	90.00	24.00	M		Locus	Iron Object	(a)
XX	(a)	98.00	36.00	M		Locus	Iron Object	(a)
YY	(a)	117.00	36.00	M		Locus	Iron Object	(a)
ZZ	(a)	128.00	25.00	M		Locus	Iron Object	(a)

Notes:
GEO = Letter designating anomaly assigned by geophysicist
PSAP = Number designating anomaly assigned by archaeologist
Grid North and Grid East = Grid coordinates used by geophysicist
Type R = Resistance anomaly, M = Magnetic anomaly
Value = Relative magnitude of R or M value
Description = General characteristics of anomaly
Interpretation = Cultural interpretation of anomaly by geophysicist prior to ground truthing
Test. Results = Results of ground truthing by archaeologist
(a) = no ground truthing

Table 8: Results of Anomaly Tests at Army City Site (14RY3193).
(From Kreisa and Walz 1997:93 Table 8).

Test	Artifact Count	Artifact Weight	Comments	Interpretation
1	1	13.3	Disturbed Profile at 25-30 cmbs	Possible Feature
2	2	3.6	Disturbed Profile at 25-35 cmbs	Possible Feature
3	40	26.8	Disturbed Profile at 25-60 cmbs	Possible Feature
4	23	275.9	Many Concrete Fragments in Profil	Possible Feature
5	2	2.9	A-AB Profile	Non-Cultural
6	4	17.3	Disturbed Profile at 50-70 cmbs	Possible Feature
7	128	1498.8	Concrete Pad at 65 cmbs	Feature
8	19	114.3	A-AB Profile	Non-Cultural
9	71	279.3	Cinder Lense at 20 cmbs	Possible Feature
10	12	22.2	Disturbed Profile at 20-70 cmbs	Possible Feature
11	15	42.4	Disturbed Profile at 20-55 cmbs	Possible Feature
12	13	15.5	Disturbed Profile at 30-55 cmbs	Possible Feature
13	64	169.1	A-AB-B Profile	Non-Cultural
14	20	127	Disturbed Profile at 25-55 cmbs	Possible Feature
15	3	15.6	A-AB Profile	Non-Cultural
16	62	288.9	Disturbed Profile at 30-60 cmbs	Possible Feature
17	2	8.1	A-AB Profile	Non-Cultural
18	0	0	A-AB Profile	Non-Cultural
19	2	17.3	A-AB Profile	Non-Cultural
20	0	0	A-AB Profile	Non-Cultural
21	40	242.2	A-AB Profile	Non-Cultural
22	0	0	Disturbed Profile at 30-60 cmbs	Possible Feature
23	4	53.8	Disturbed Profile at 35-55 cmbs	Possible Feature
24	1	0.6	A-AB Profile	Non-Cultural
25	0	0	A-AB Profile	Non-Cultural
26	0	0	A-AB Profile	Non-Cultural
27	0	0	A-AB Profile	Non-Cultural
28	3	63.7	Disturbed Profile at 30-55 cmbs	Possible Feature
29	2	110.4	A-AB Profile	Non-Cultural
30	0	0	A-AB Profile	Non-Cultural
31	1	3.2	A-AB Profile	Non-Cultural
32	0	0	A-AB Profile	Non-Cultural
33	7	19.4	Disturbed Profile at 30-65 cmbs	Possible Feature
34	3	8.7	Disturbed Profile at 30-65 cmbs	Possible Feature
35	0	0	A-AB Profile	Non-Cultural
36	0	0	A-AB Profile	Non-Cultural
37	0	0	A-AB Profile	Non-Cultural
38	3	34.7	A-AB Profile	Non-Cultural
39	0	0	A-AB Profile	Non-Cultural
40	0	0	A-AB Profile	Non-Cultural
41	2	4.8	A-AB Profile	Non-Cultural
42	0	0	A-AB Profile	Non-Cultural
43	2	20.9	Disturbed Profile at 30-65 cmbs	Possible Feature

Note: cmbs=centimeters below surface. Weight in grams.

Table 9: Description of Geophysical Anomalies at Station Agent Site (14GE3108).
(After Somers 1997b:62-64).

GEO	PSAP	North	East	Type	Value	Description	Interpretation	Test. Result
F	S-1, S-2	4.00	71.00	R	High	(b)	Stone, cement, and/or gravel pad	Architectural Feature
D	S-3, S-4	8.00	37.00	R	High	(b)	Large pit filled with stone or cement	Architectural Feature
E	S-5, S-6	14.00	59.00	R	High	(b)	Stone, cement, and/or gravel	No Feature
AA	A-1	6.50	15.50	M		linear	pipe, drain, or trench	No Feature
DD	A-2	3.00	62.00	M		(b)	one or two large pieces of iron	No Feature
EE	A-3	11.00	84.50	M		(b)	pipe or other long metal object	No Feature
GG	A-4	6.00	5.50	M		(b)	road, path, bulldozer tailings	No Feature
A	(a)	37.00	2.50	R	High	(b)	Stone, cement, and/or gravel	(a)
B	(a)	10.50	16.00	R	High	(b)	Stone, cement, and/or gravel	(a)
C	(a)	3.50	25.00	R	High	(b)	Stone, cement, and/or gravel	(a)
G	(a)	8.00	100.00	R	High	(b)	Stone, cement, and/or gravel pad	(a)
H	(a)	31.00	59.00	R	High	(b)	Stone, cement, and/or gravel pad	(a)
I	(a)	30.00	23.00	R	Low	(b)	backfilled or undisturbed deposits of loam and/or clay	(a)
J	(a)	11.00	36.00	R	Low	(b)	backfilled or undisturbed deposits of loam and/or clay	(a)
K	(a)	5.00	59.00	R	Low	(b)	backfilled or undisturbed deposits of loam and/or clay	(a)
L	(a)	36.00	54.00	R	Low	(b)	backfilled or undisturbed deposits of loam and/or clay	(a)
M	(a)	10.00	98.00	R	Low	(b)	backfilled or undisturbed deposits of loam and/or clay	(a)
BB	(a)	13.00	12.00	M		linear	pipe, drain, or trench	(a)
CC	(a)	6.50	30.50	M		(b)	one or two large pieces of iron	(a)
FF	(a)	4.00	5.50	M		(b)	road, path, bulldozer tailings	(a)
HH	(a)	8.50	5.50	M		(b)	road, path, bulldozer tailings	(a)
II	(a)	6.00	44.00	M		circular cluster	architectural feature?	(a)

Notes:
GEO = Letter designating anomaly assigned by geophysicist
PSAP = Number designating anomaly assigned by archaeologist
Grid North and Grid East = Grid coordinates used by geophysicist
Type R = Resistance anomaly, M = Magnetic anomaly
Value = Relative magnitude of R or M value
Description = General characteristics of anomaly
Interpretation = Cultural interpretation of anomaly by geophysicist prior to ground truthing
Test. Results = Results of ground truthing by archaeologist
(a) = No ground truthing
(b) = Detailed descriptions not provided

Table 10: Results of Anomaly Tests at Station Agent Site (14GE3108) (From Kreisa and Walz 1997:119 Table 14).

Test	Target	Artifact Count	Artifact Weight	Result
S-1	Interior Structure	6	113.1	Dense gravel layer/walkway at 20 cmbs
S-2	Exterior Structure	32	77.4	Cinder layer at 30 cmbs, no feature identified
S-3	Exterior Structure	27	238.5	No structural feature identified
S-4	Interior Structure	4	118.4	Concrete pad encountered at 15 cmbs
S-5	Exterior Structure	0	0	No structural feature identified
S-6	Interior Structure	3	422	No structural feature identified
A-1	Pipe/Drain	0	0	No feature identified
A-2	Iron Cluster	16	30.2	Artifacts consist of cinders
A-3	Pipe/Drain	7	12.9	No feature identified
A-4	Road/Path	25	121.3	No feature identified

Note:
cmbs=centimeters below surface
interior/exterior structure=within/outside of an anomaly interpreted as a structure

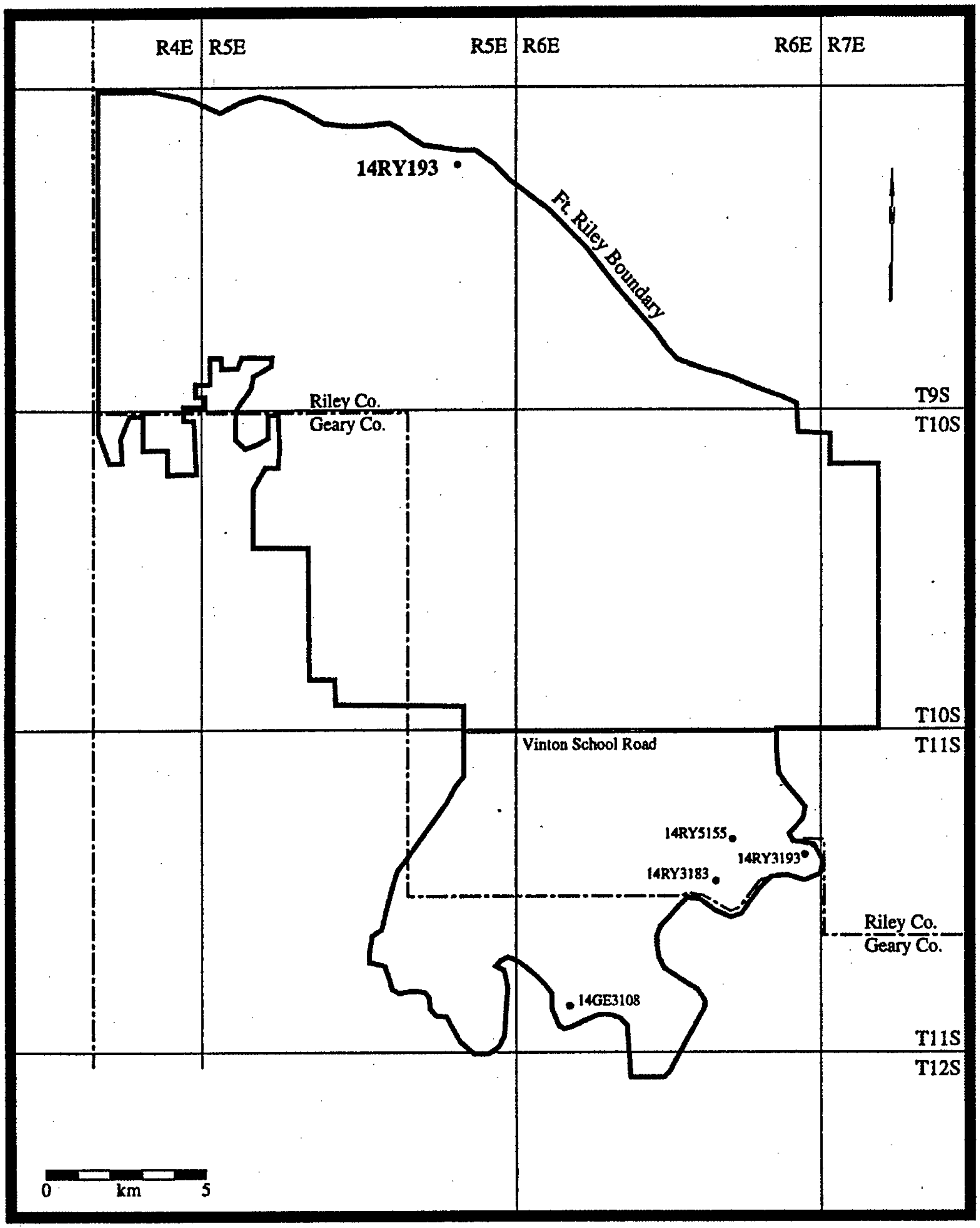

Figure 1. Location of the Project Sites at Ft. Riley, Kansas. (From Kreisa and Walz 1997:3).

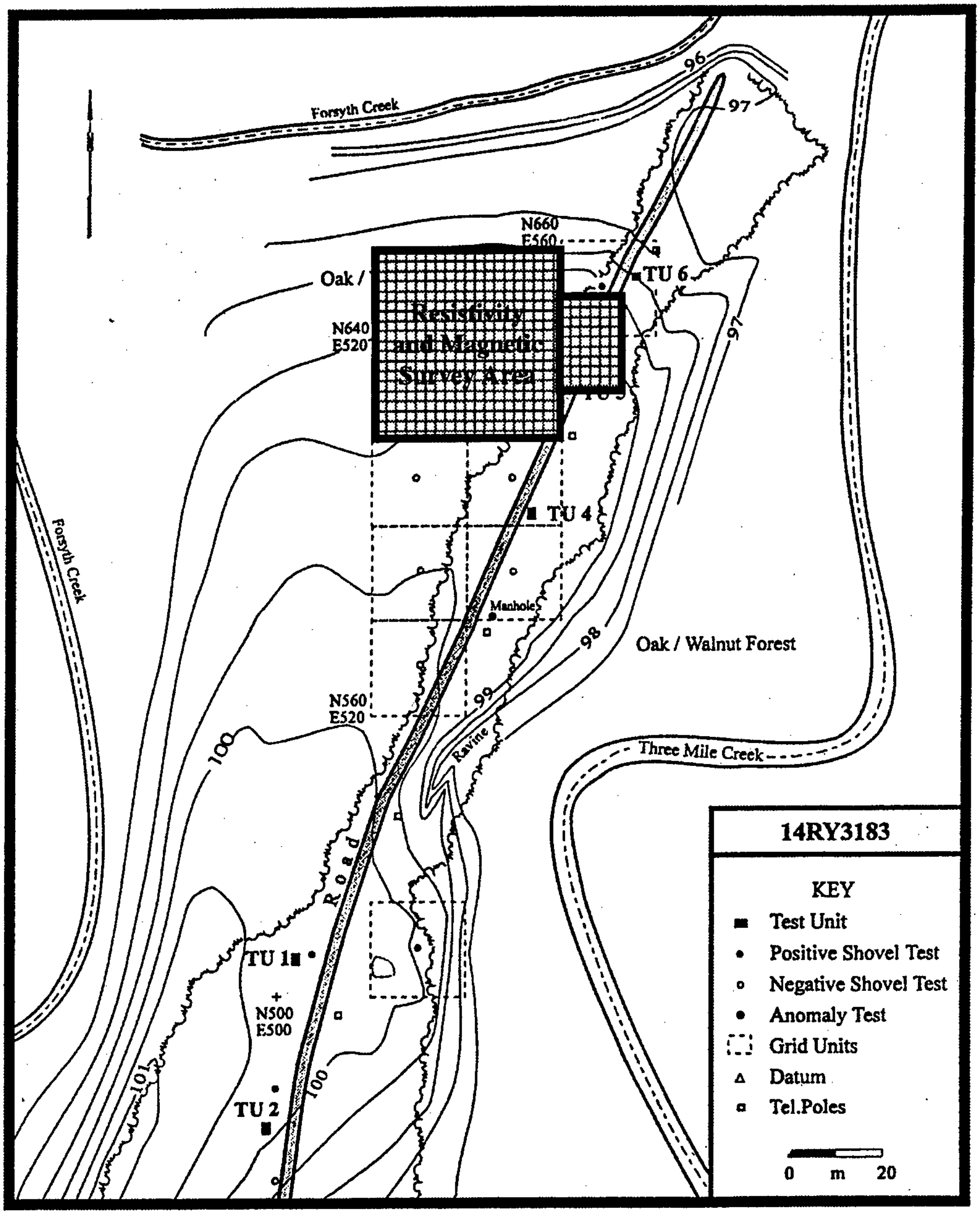

Figure 2. Site Plan of 14RY3183 (ForThree Site) Showing Geophysical Survey Units. (From Kreisa and Walz 1997:68).

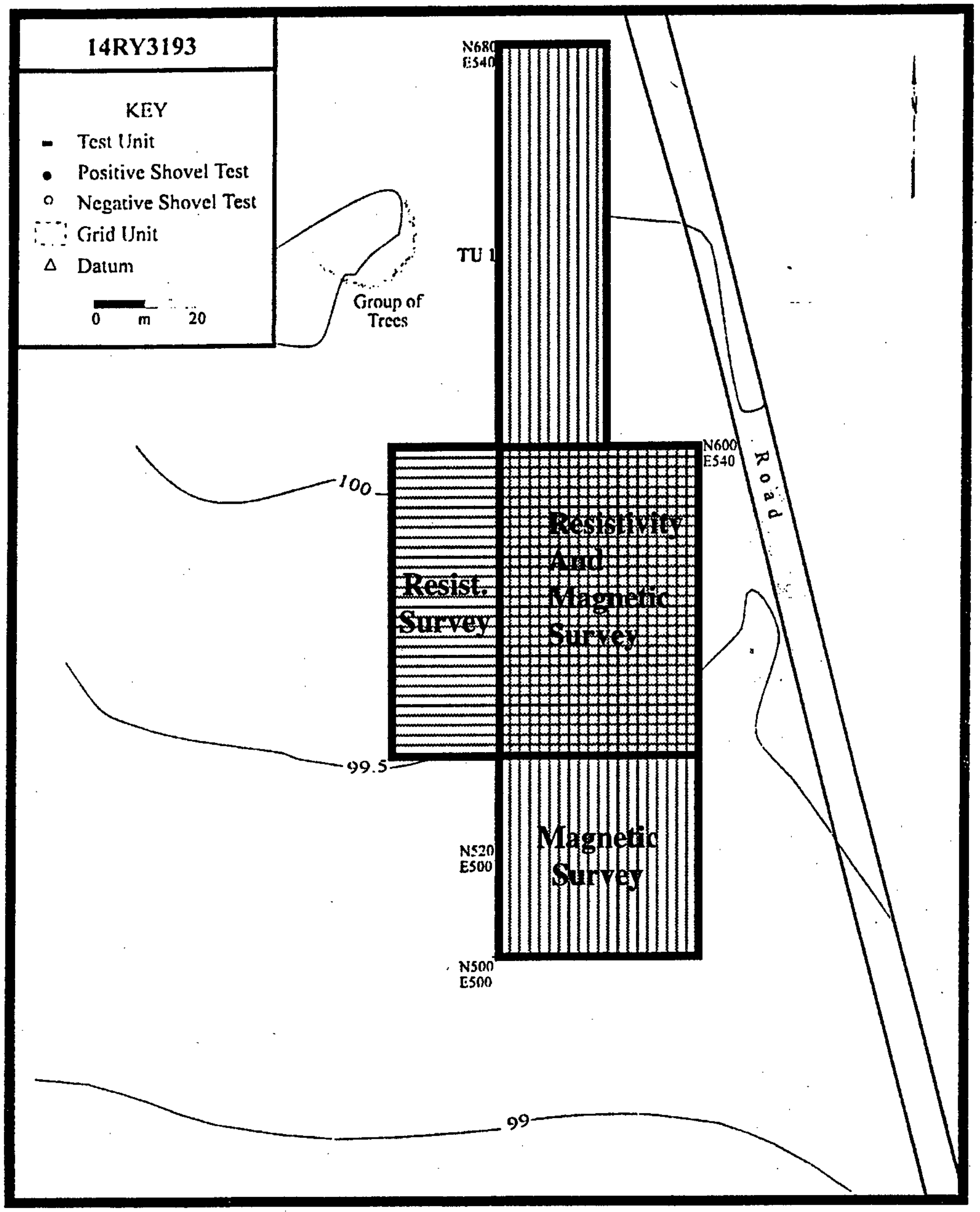

Figure 3. Site Plan of a Portion of 14RY3193 (Army City Site) Showing Geophysical Survey Units West of Fourth Street. (From Kreisa and Walz 1997:88).

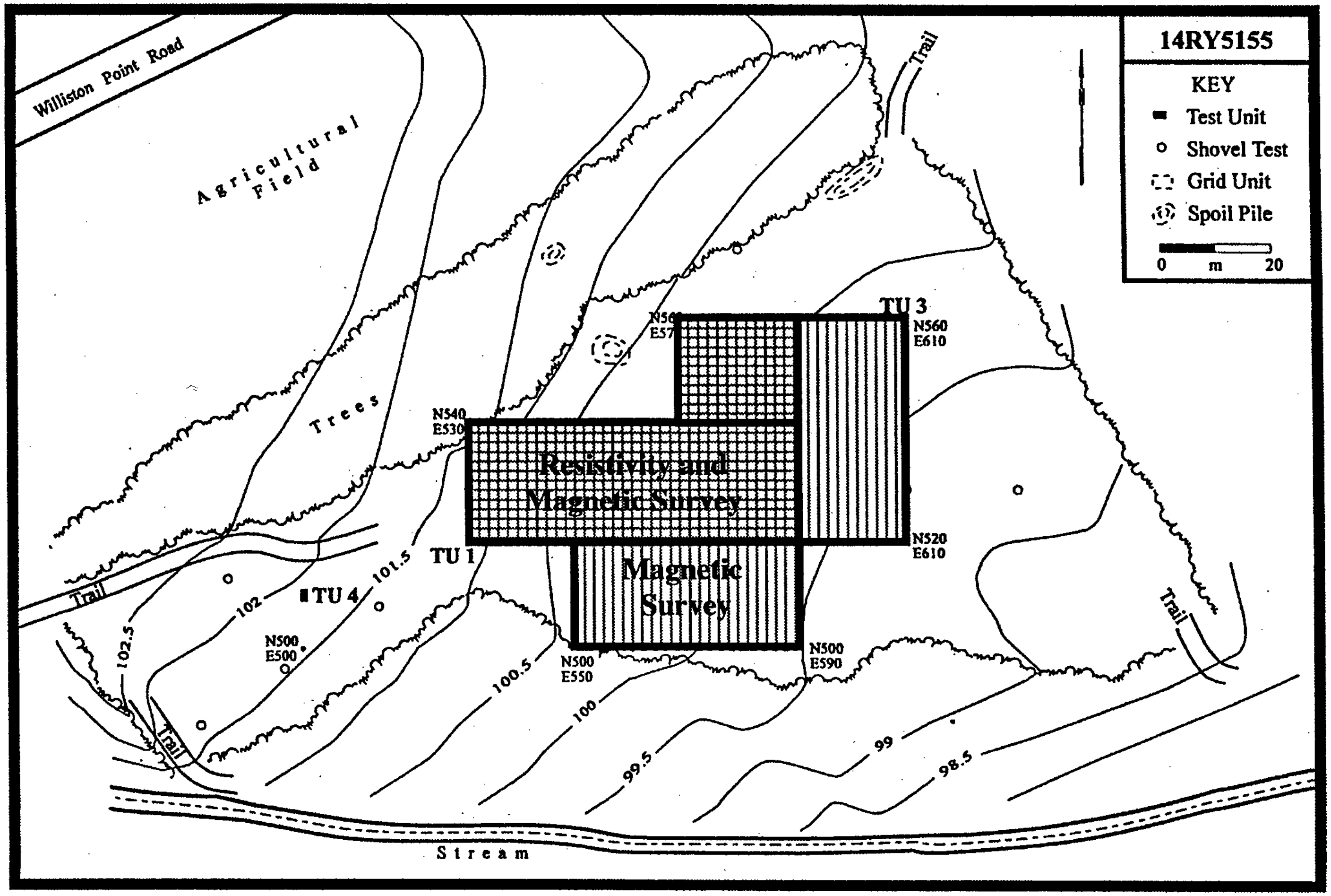

Figure 4. Site Plan of 14RY5155 Showing Geophysical Survey Units. (From Kreisa and Walz 1997:102).

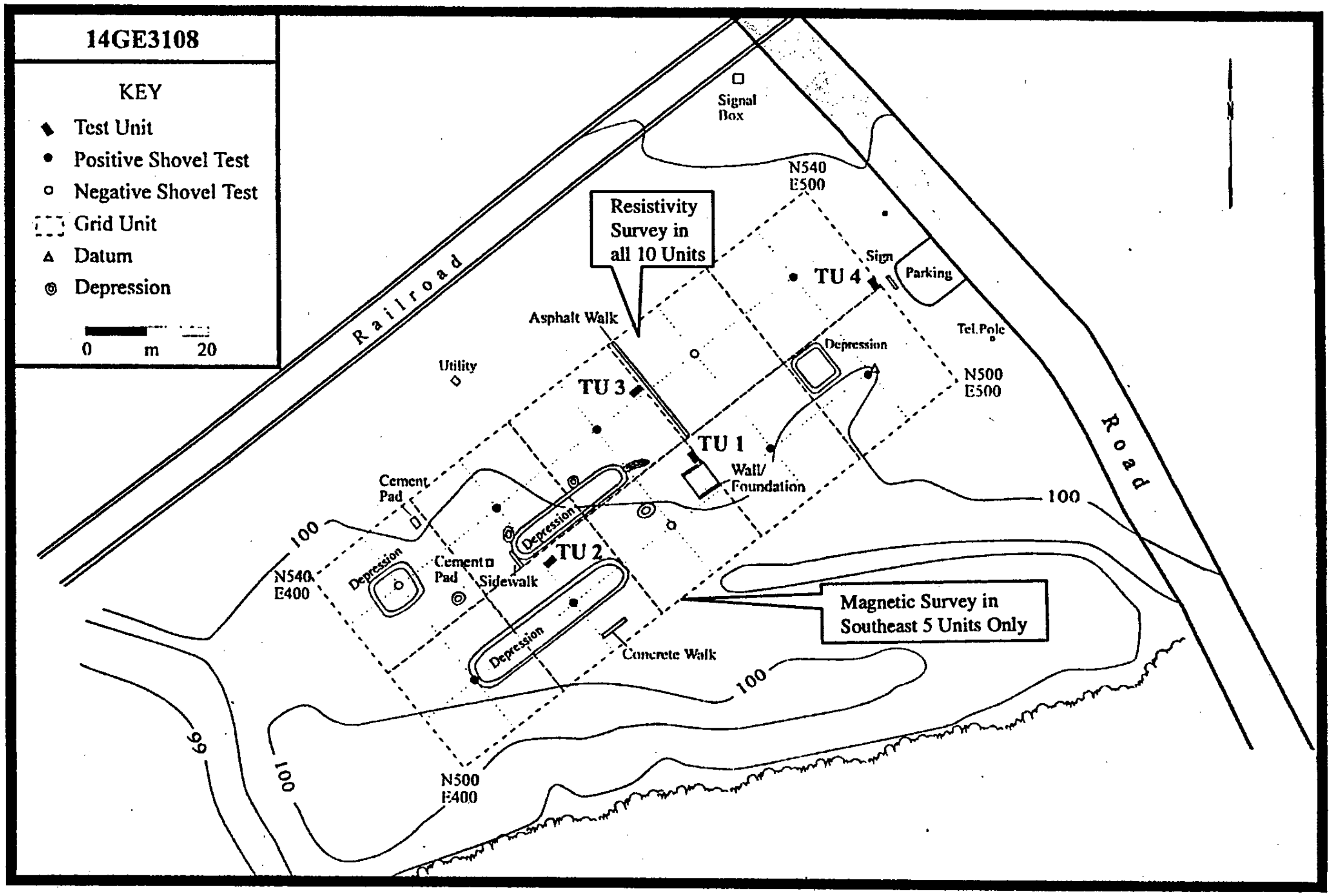

Figure 5. Site Plan of 14GE3108 (Station Agent Site) Showing Geophysical Survey Units. (From Kreisa and Walz 1997:113).

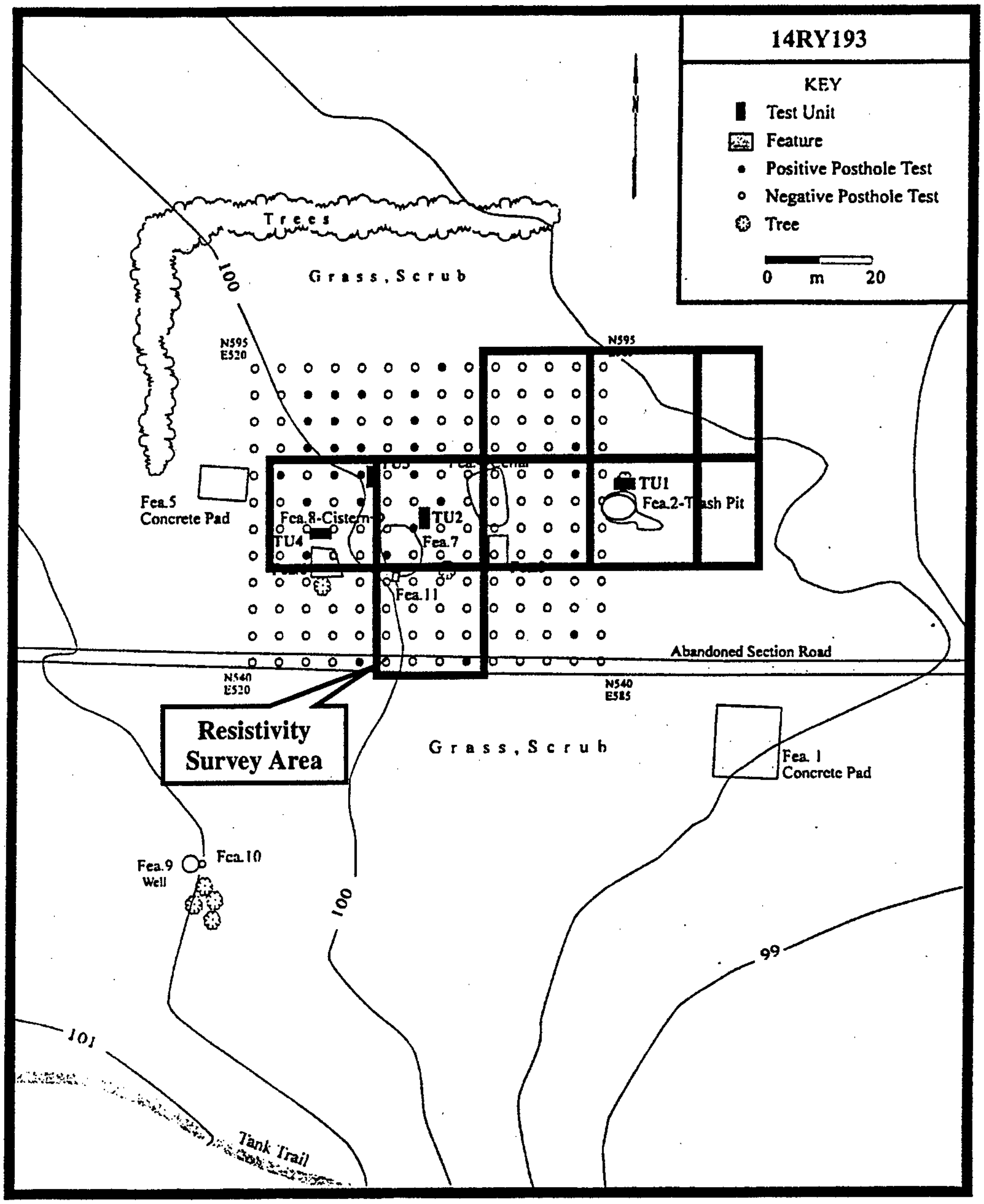

Figure 6. Site Plan of 14RY193 (Thomas R. Hair Site) Showing Geophysical Units. (From Halpin 1997:56)

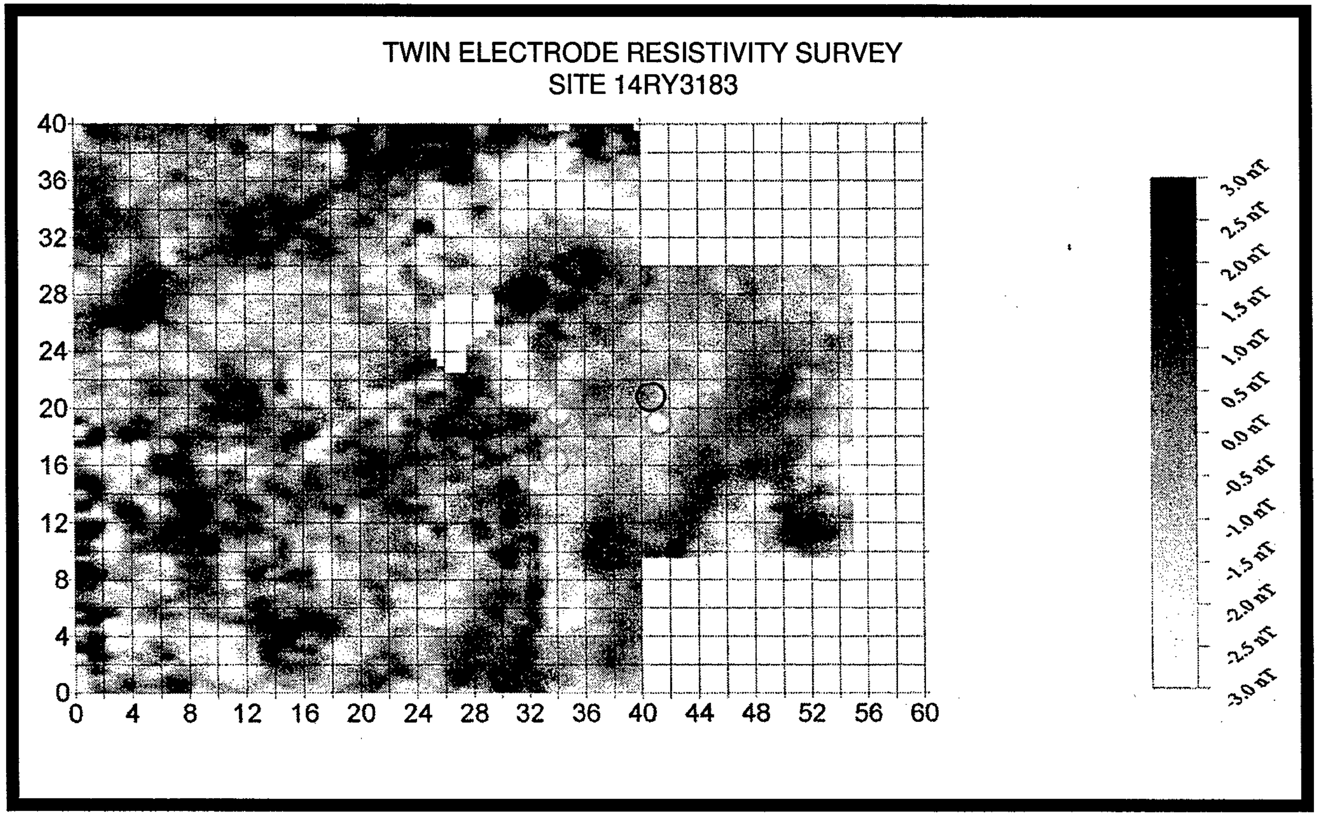

Figure 7. Resistivity Map of 14RY3183 (ForThree Site) Showing High-Pass Filtered Data. Grid Coordinates in Meters. Note: Open Circles Indicate Suggested Locations For Ground Truthing Units. (From Somers 1997).

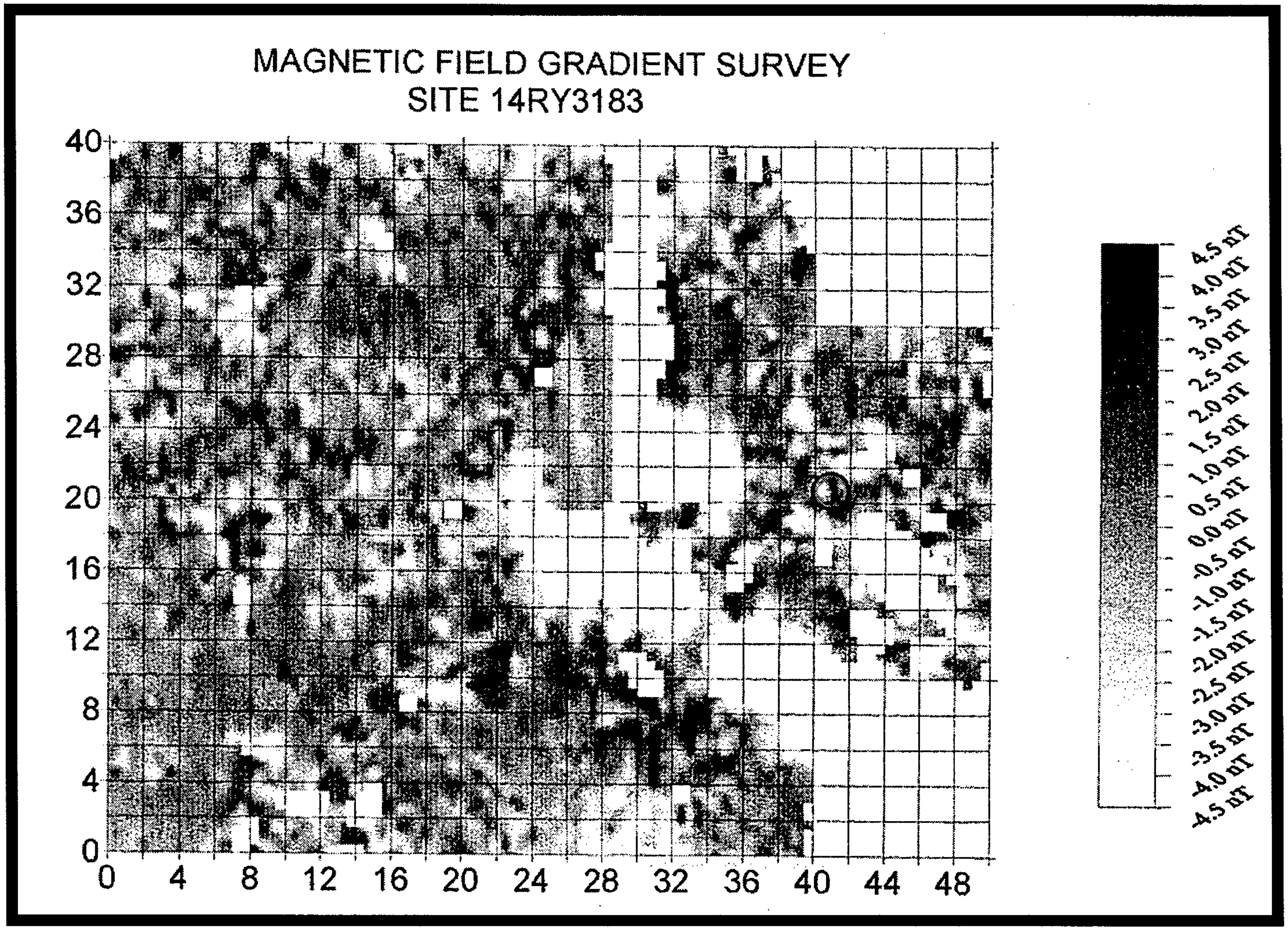

Figure 8. Magnetic Map of 14RY3183 (ForThree Site) Showing All Data After Iron Removal. Grid Coordinates in Meters. (From Somers 1997).

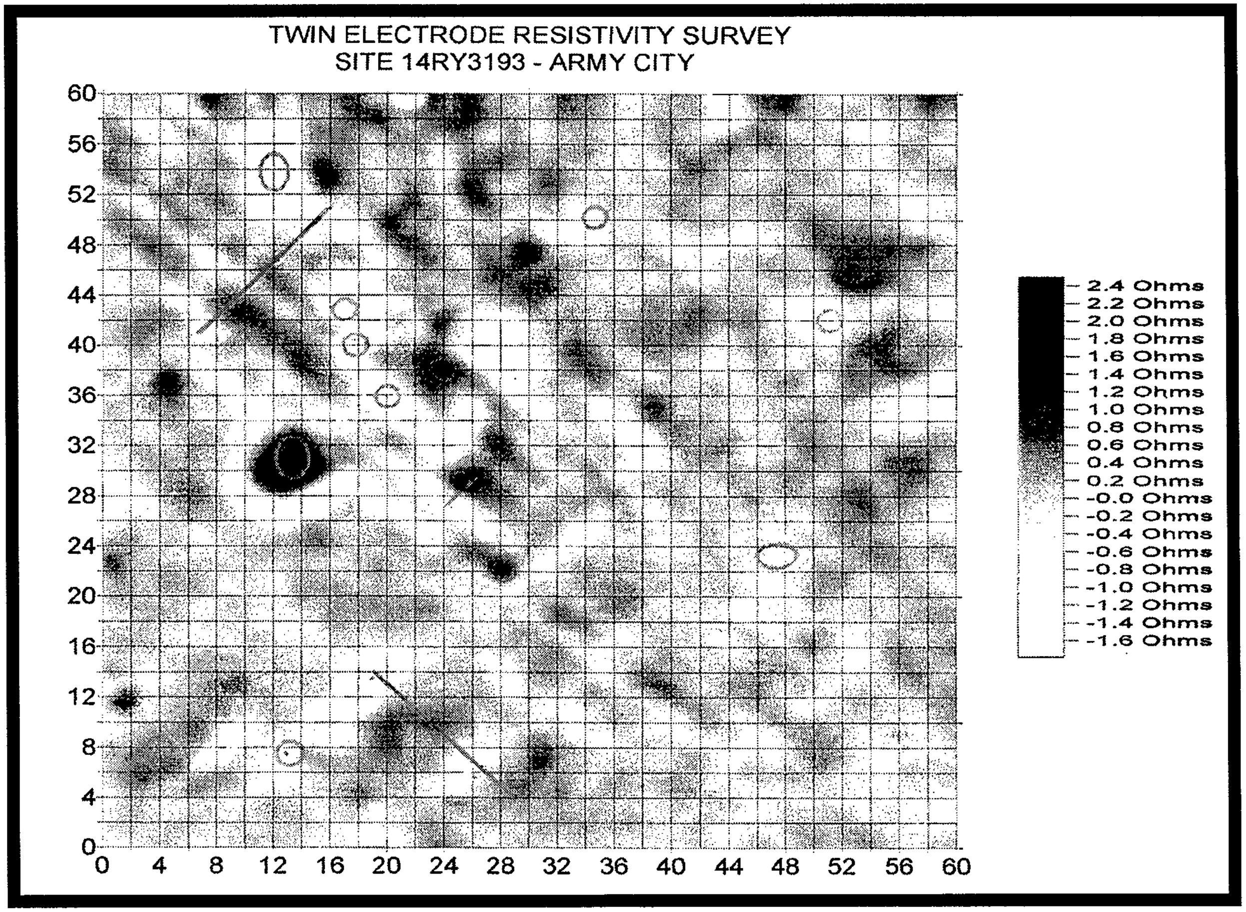

Figure 9. Resistivity Map of 14RY3193 (Army City Site) Showing High Pass Filtered Data, 1 Meter Depth. Grid Coordinates in Meters. Note: Lines and Open Circles Indicate Suggested Locations for Ground Truthing Units. (From Somers 1997).

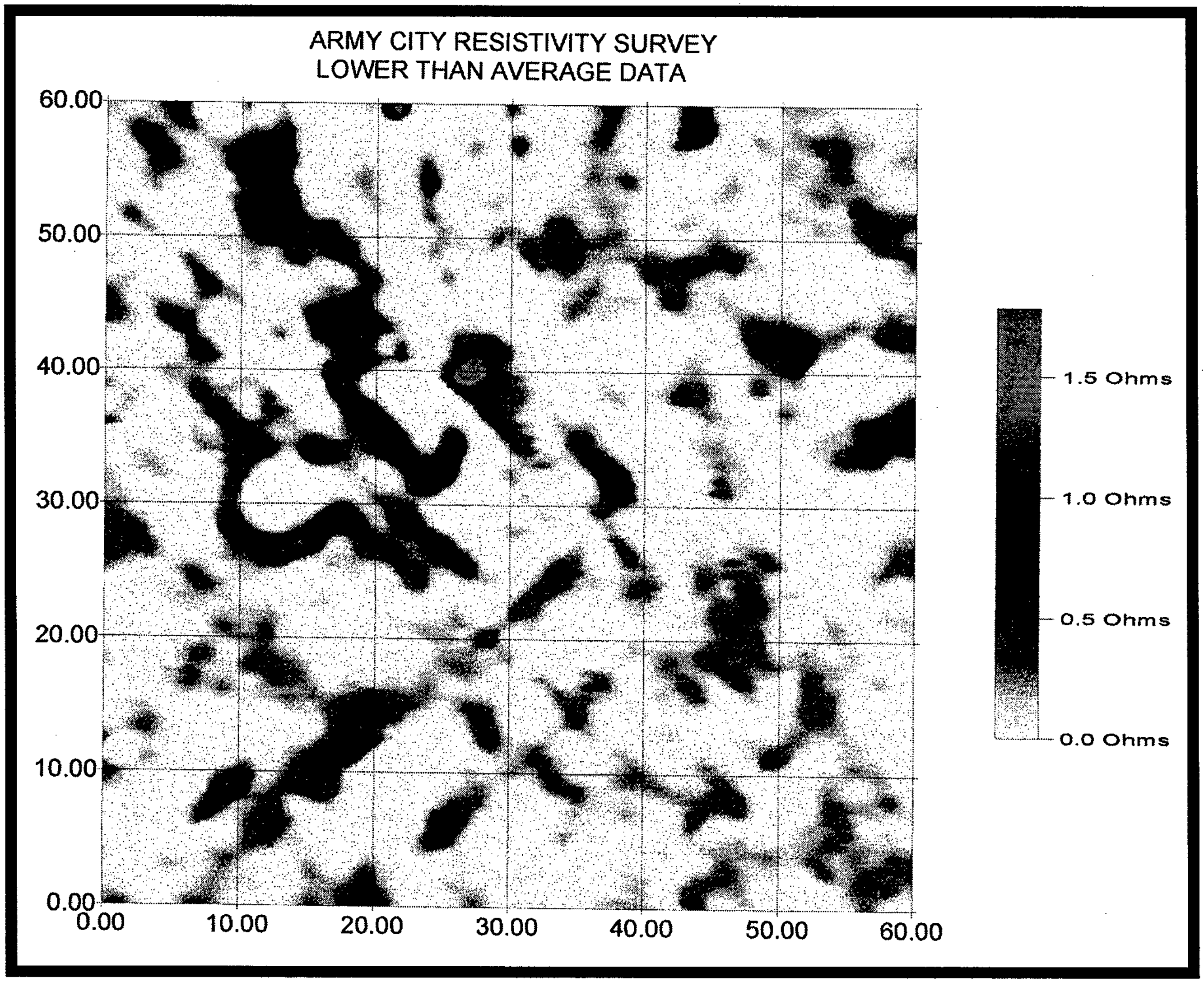

Figure 10. Resistivity Map of 14RY3193 (Army City Site) Showing Lower Than Average Data, 1 Meter Depth. Grid Coordinates in Meters. (From Somers 1997).

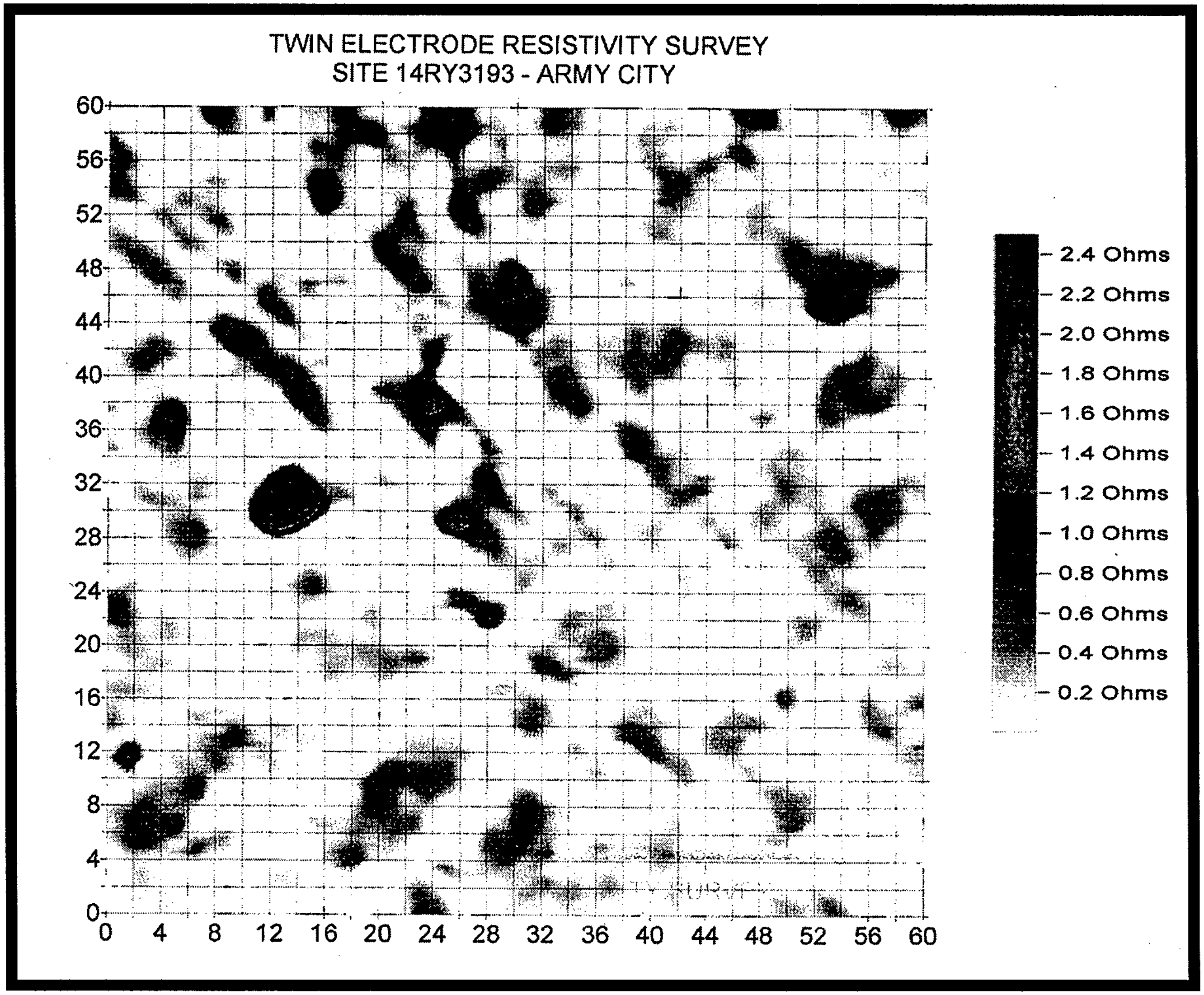

Figure 11. Resistivity Map of 14RY3193 (Army City Site) Showing Greater Than Average Data, 1 Meter Depth. Grid Coordinates in Meters. (From Somers 1997).

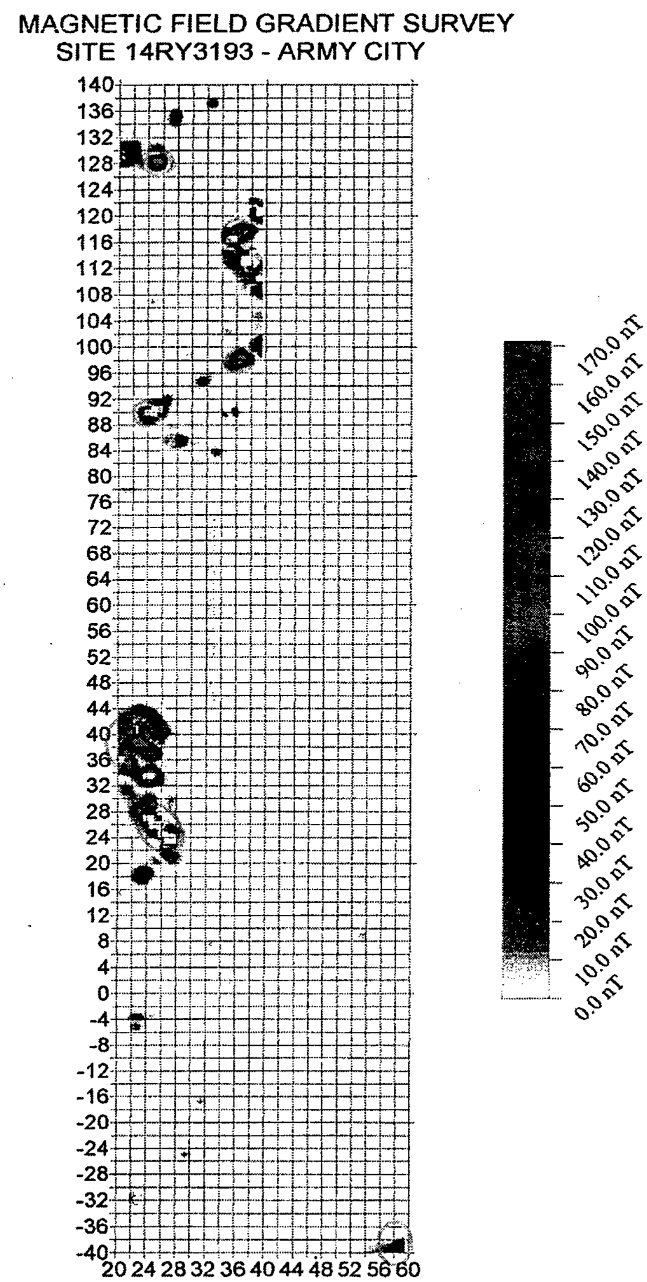

Figure 12. Magnetic Map of 14RY3193 (Army City Site) Showing Iron Features. Grid Coordinates in Meters. (From Somers 1997).

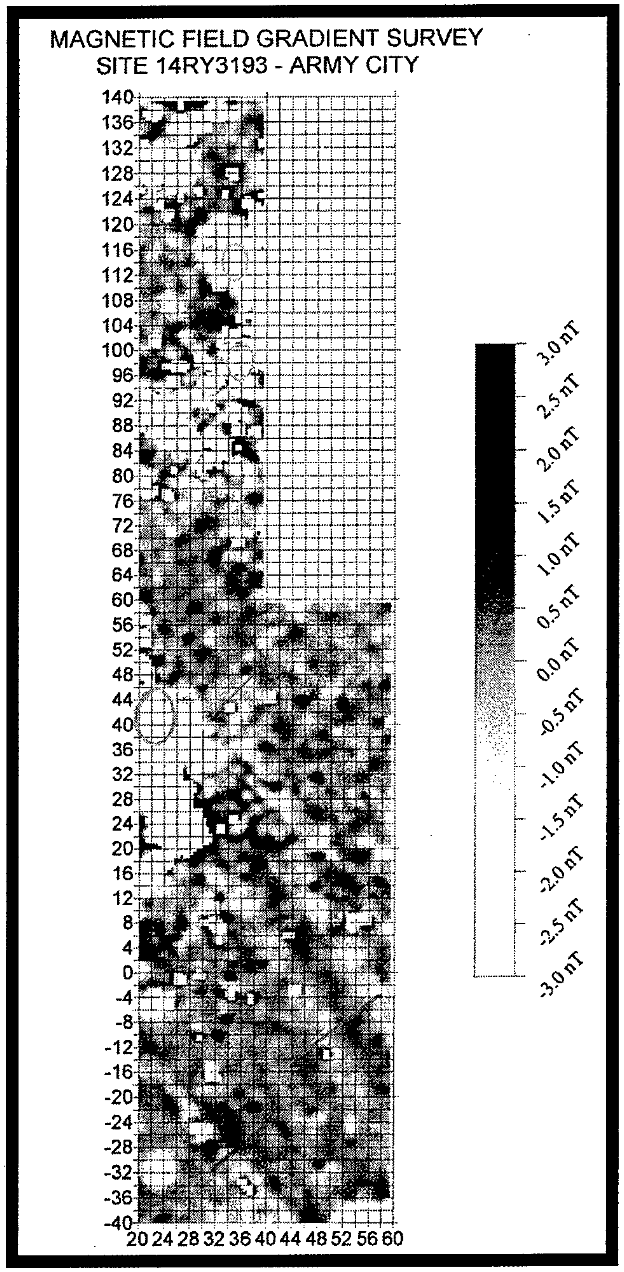

Figure 13. Magnetic Map of 14RY3193 (Army City Site) Showing All Low Level Data. Grid Coordinates in Meters. Note: Lines and Open Circles Indicate Suggested Locations for Ground Truthing Units. (From Somers 1997).

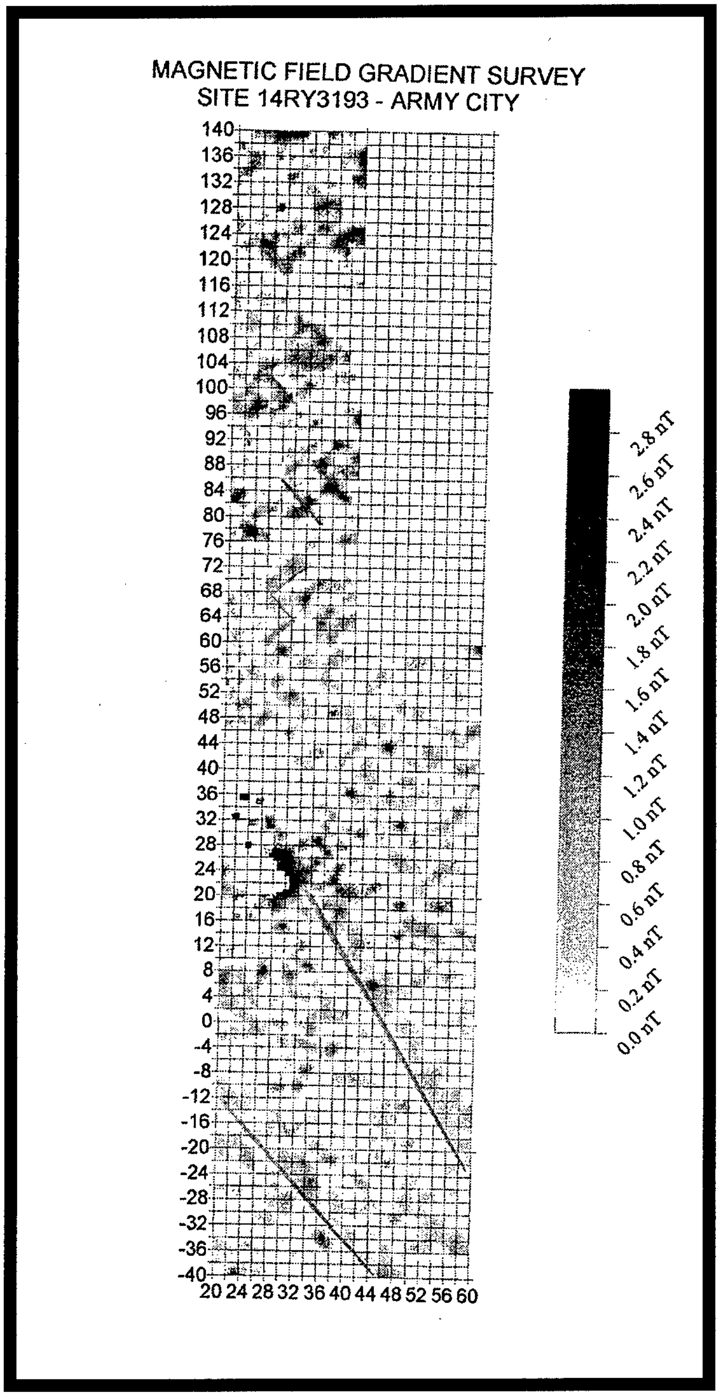

Figure 14. Magnetic Map of 14RY3193 (Army City Site) Showing Positive Magnetic Data Associated with Disturbed Soils. Grid Coordinates in Meters. Note: Lines Drawn On Map Emphasize Linear Patterns in Data. (From Somers 1997).

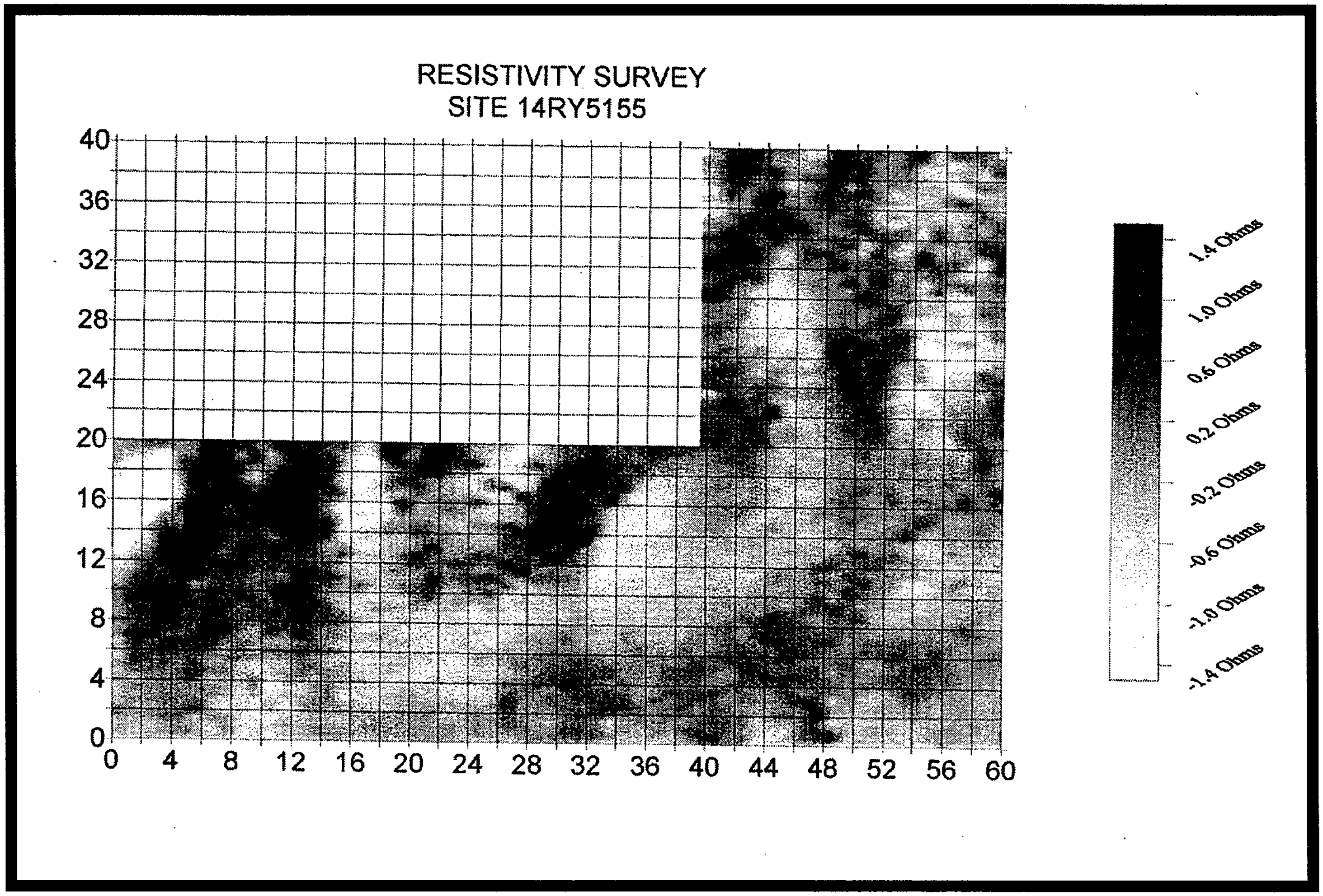

Figure 15. Resistivity Map of 14RY5155 Showing High-Pass Filtered Data. Grid Coordinates in Meters. (From Somers 1997).

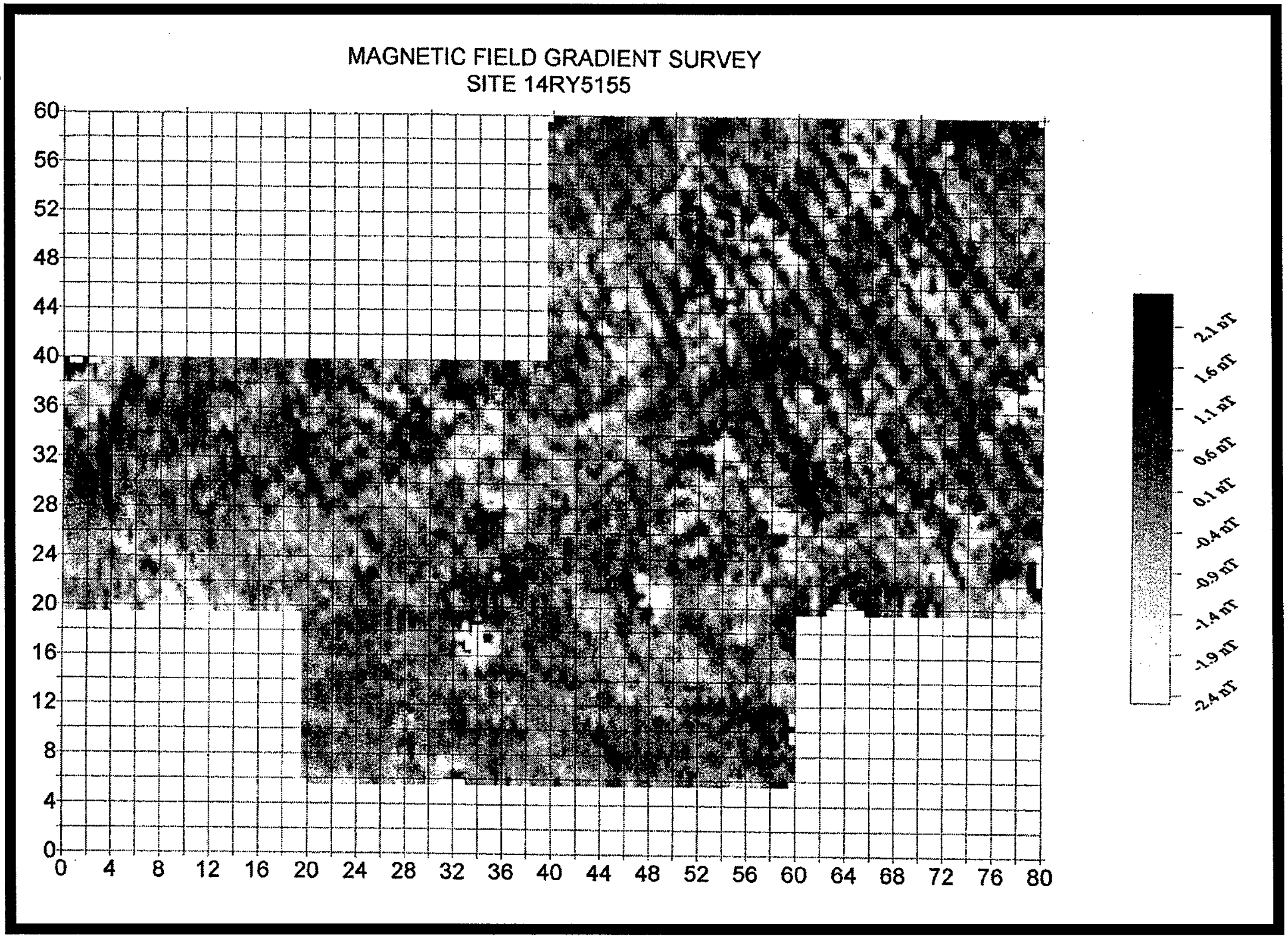

Figure 16. Magnetic Map of 14RY5155 Showing All Data. Grid Coordinates in Meters. (From Somers 1997).

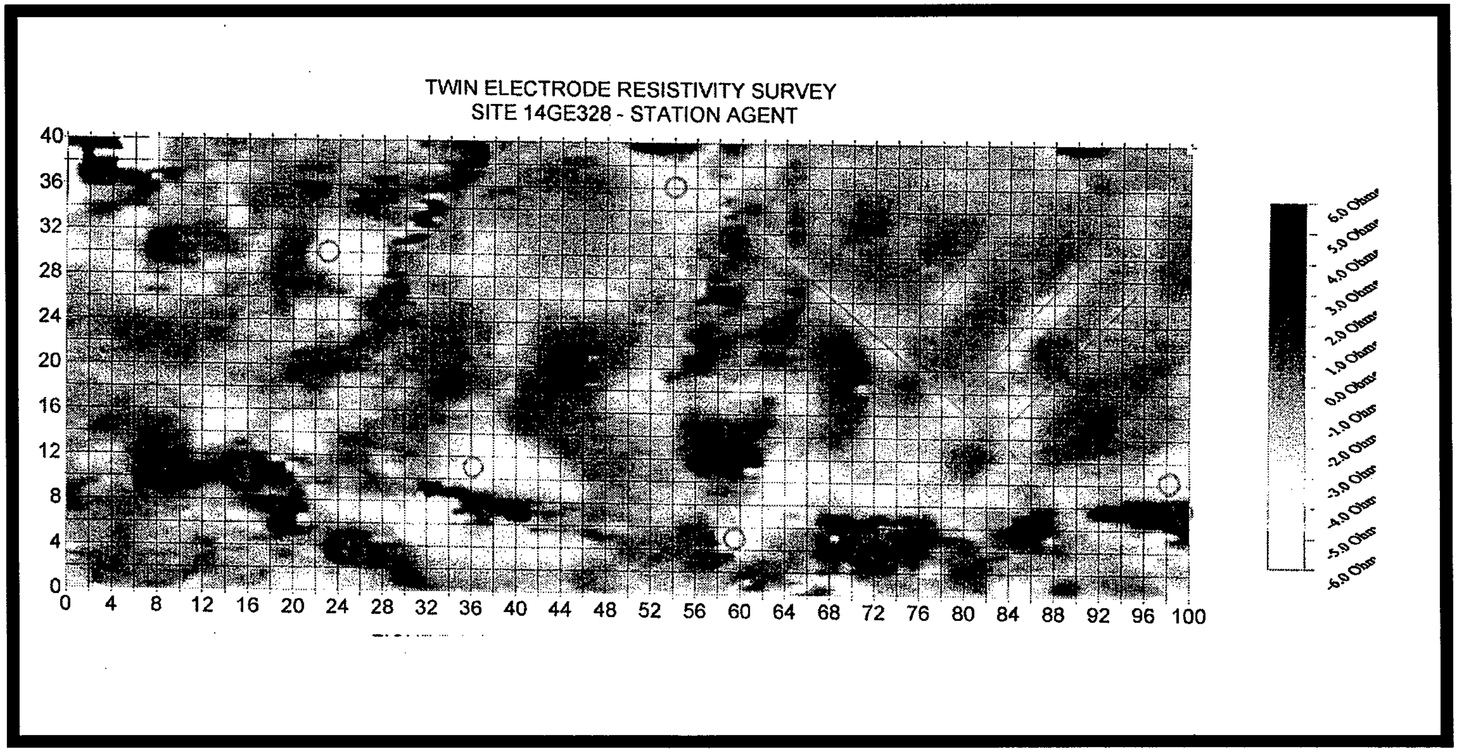

Figure 17. Resistivity Map of 14GE3108 (Station Agent Site) Showing High Pass Filtered Data. 1 Meter Depth, Grid Coordinates in Meters. Note: Open Circles Indicate Suggested Locations for Ground Truthing Units and Lines Emphasize Linear Patterns in the Data. (From Somers 1997).

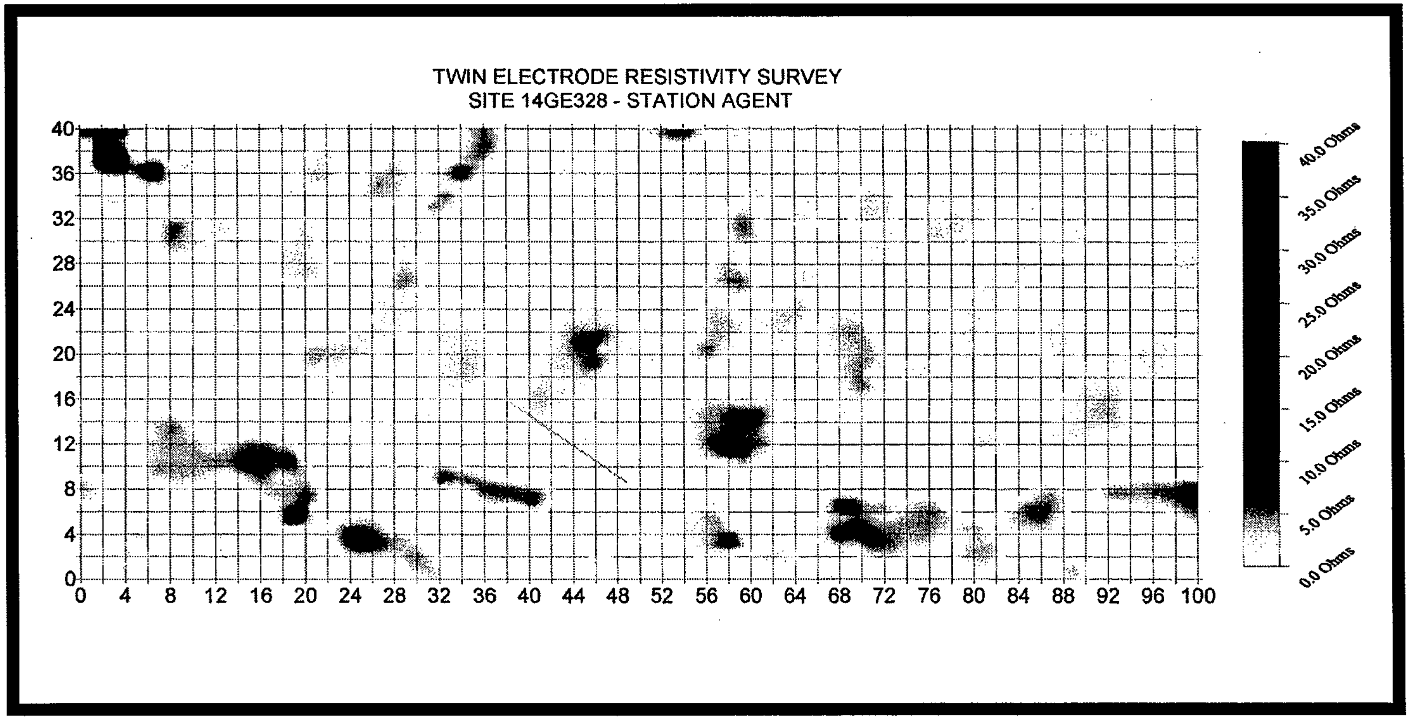

Figure 18. Resistivity Map of 14GE3108 (Station Agent Site) Showing Greater Than Average Data. 1 Meter Depth, Grid Coordinates in Meters. Note: Line Drawn On Map Indicates Suggested Location for a Ground Truthing Unit. (From Somers 1997).

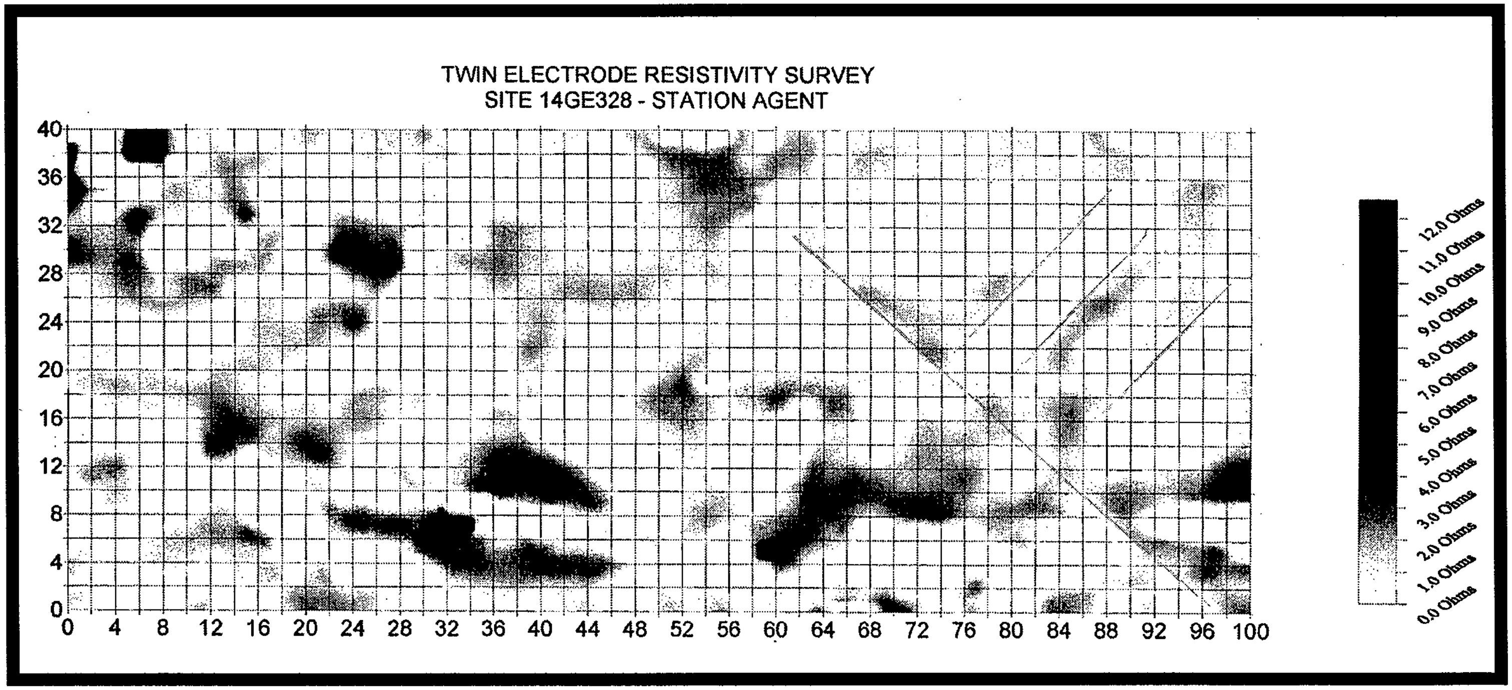

Figure 19. Resistivity Map of 14GE3108 (Station Agent Site) Showing Less Than Average Data. 1 Meter Depth, Grid Coordinates in Meters. Note: Lines Drawn on Map Emphasize Linear Patterns in the Data. (From Somers 1997).

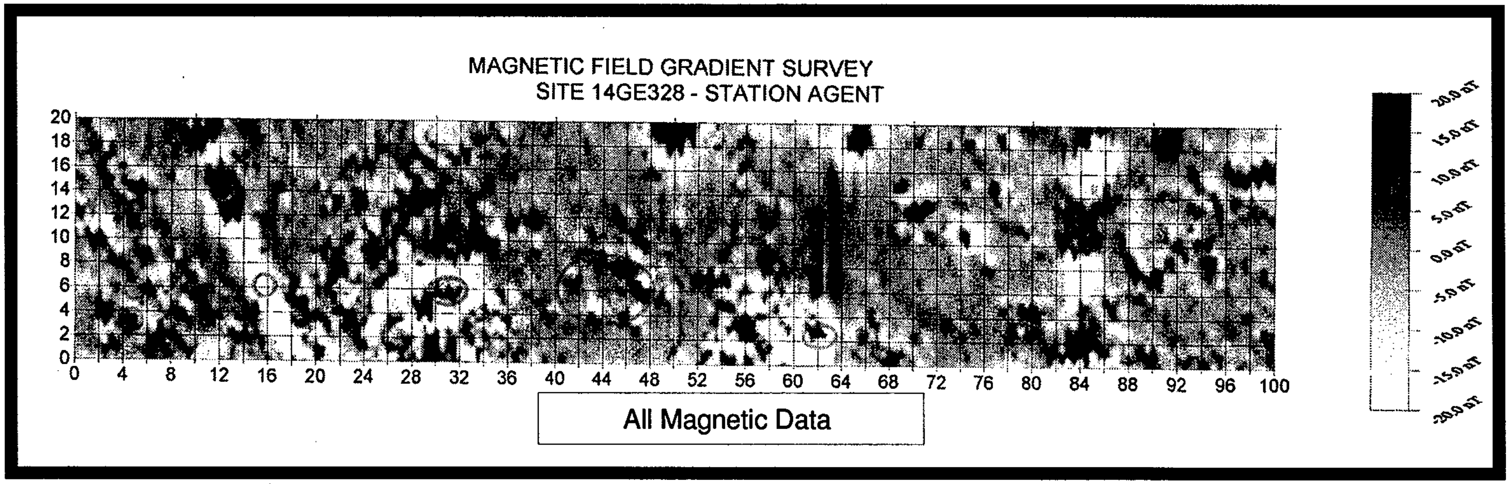

Figure 20. Magnetic Map of 14GE3108 (Station Agent Site) Showing All Data. Grid Coordinates in Meters. Note: Open Circles Drawn on Map Indicate Suggested Locations for Ground Truthing Units. (From Somers 1997).

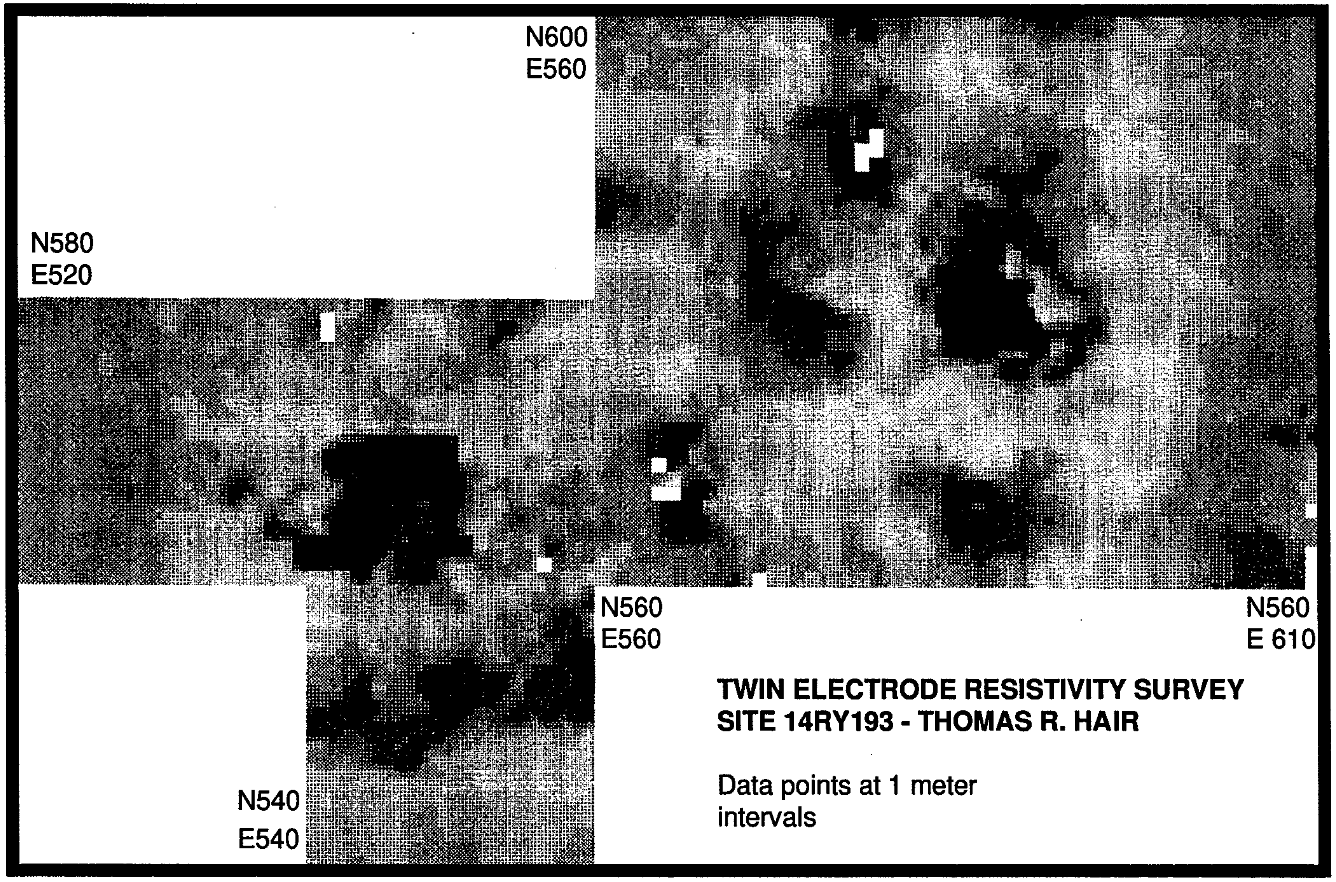

Figure 21. Resistivity Map of 14RY193 (Thomas R. Hair Site) Showing All Data. (Somers n.d.).

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This final chapter reiterates the need for an improved site assessment strategy, and then summarizes the results of a comparison of the traditional and geophysical assessment strategies at a number of Ft. Riley sites.

To be eligible for the National Register, an archaeological site must meet at least one of four criteria. Archaeological sites are most commonly evaluated using Criterion D, which requires a site to have the potential to provide important information about prehistory or history. The importance of the information a site can provide is assessed using a historic (or prehistoric) context. A site that cannot be assigned to one or more time intervals or culture-historical units cannot have a meaningful historic context and so cannot be eligible for the National Register. Eligibility also requires that a site possess integrity, a state of preservation that allows the site to convey it's significance (USDI 1995).

The states vary somewhat in how the National Register eligibility criteria are applied. Sites that represent very rare resource categories (e.g., lithic scatters comprised primarily of Paleoindian materials) may be viewed as eligible even if there is little or no evidence of intact (sub-plow zone) deposits. In most cases, however, integrity and NRHP eligibility requires that a site have intact, culturally enriched sediments. These deposits may be horizontally extensive cultural strata (e.g., midden) that have not been disturbed by historic plowing or other postdepositional processes. Such deposits are sometimes stratified, so that vertical provenience provides the basis for a relative chronology. Horizontally extensive deposits may also provide an opportunity to identify the horizontal patterning of past activities (activity areas) and/or spatially discrete occupations (component patterning). Thus, sites that have sub-plow zone cultural strata are generally eligible for the National Register, (i.e., they generally have integrity, known chronological affiliations, and can provide important information).

At many sites, the horizontally extensive cultural strata have long-since been incorporated into the plow zone or an A horizon that has been thoroughly mixed by bioturbations or modern cultural impacts (e.g., vehicle traffic). At many such sites, however, the lower portions of discrete cultural deposits such as storage or cooking pits, architectural remains, or other features, protrude below the disturbed uppermost strata. The lower portions of these discrete features and their artifactual contents often provide important information about particular time intervals and/or activities. On balance, some archaeological sites are characterized by intact, horizontally extensive deposits, some by the remains of discrete subsurface features, some by both types of deposit, and some by neither type.

Traditional Site Assessments

Assessing an archaeological site's eligibility for the National Register typically includes an examination of existing records, (for historic sites, this includes maps and archives), a program of test excavations to document the nature, chronology, and integrity of site deposits, and the use of a historic context to assess the importance of information the site may be able to provide. Traditional site assessment field programs vary widely from state to state, but are generally based on controlled surface collections, the hand excavation of small shovel or posthole tests, and a small number of test units.

Traditional site assessments are expensive because they are labor intensive. Site assessments conducted in Kansas since 1990 have typically involved the excavation of test units exposing about 6 m^2, as well as an average of about 20 shovel tests. The mean cost of the 25 assessments documented in this study was $8,005.05. No adjustments have been made for the effects of inflation, and it is safe to assume that the mean cost of site assessments conducted recently in Kansas is greater than $8,000. For example, the mean cost for the traditional assessment of 13 sites investigated at Ft. Riley in 1997 was $10,929.

Traditional site assessments are, in many cases, unreliable. The reliability of a site assessment is largely a result of two factors: the nature of site deposits and sample size. The excavation of regularly spaced shovel or posthole tests and a few test units is, in many cases, adequate to determine the presence or absence of horizontally extensive cultural strata. But it is highly unlikely that this excavation strategy will result in the documentation of even one hearth or pit feature. Such features are generally small (1 meter or less in diameter), widely spaced, and occur in relatively low frequencies at most sites. On balance, the traditional site assessment strategy represents a reasonably reliable approach to assessing sites characterized by horizontally extensive deposits, but does not allow a reliable assessment of sites characterized by a number of discrete subsurface features but no horizontally extensive deposits. Thus, systematic use of the traditional site assessment strategy will result in a bias against sites characterized by features but no intact midden.

One might think that a low probability of documenting isolated features would suppress the number of sites recommended as eligible for the National Register. In fact, the reverse may be true. Archaeologists, cultural resource managers, and SHPO officials are aware of the limitations of the traditional site assessment strategy. In an effort to offset this problem, many individuals adopt a conservative approach, recommending as eligible for the National Register sites for which only the most modest of intact deposits have been documented. In the present era of decreasing federal funding for cultural resource management efforts, it would be more beneficial to the archaeological resource base--as well as to the fiscal interests of land managing agencies--to adopt a more reliable assessment strategy. A more reliable approach to site assessment would allow land managers to spend less on the preservation of marginally significant sites, but to do a better job of identifying and protecting sites that are genuinely important.

Geophysical Site Assessments

Geophysics (as the term is used here) refers to a suite of techniques capable of identifying the location and, to varying degrees, the size, shape, and depth characteristics of subsurface cultural features. The focus here is on resistivity and magnetics, two techniques that are well established, commercially available, and well suited to archaeological applications. The present study represents one aspect of a comprehensive effort by USACERL to determine if geophysical surveys combined with limited but highly targeted ground truthing can provide the basis for a site assessment strategy that is more reliable and cost effective than the traditional strategy based on hand excavation. It is useful here to outline the basic characteristics of a site assessment strategy based on geophysics.

Geophysical surveys result in the production of maps showing the location of anomalies, i.e., loci characterized by geophysical data values that differ notably from those of the surrounding area. To the extent that the anomalies correspond to cultural features, geophysical surveys can provide far more data on intra-site patterning than is generally obtained from traditional assessments. Whereas traditional assessments typically excavate less than one percent of total site area, geophysical surveys can cover large areas. The incorporation of geophysical survey techniques into the site assessment strategy will probably never entirely obviate the use of traditional excavation techniques. Ground truthing excavations are essential to determine whether the geophysical anomalies represent cultural features or natural phenomena. Additionally, an assessment of a site's eligibility for the National Register requires one to document the integrity of cultural deposits, and to ascertain the presence of chronological indicators that allow the site to be related to a historic context. Determinations of site integrity and chronology will, in virtually all cases, require excavation. Finally, some sites include horizontally extensive, intact cultural strata but few or no discrete features. Using present technology, such strata are less likely to be detected by a geophysical survey than are discrete features. Advances in geophysical technology, including the development of more sensitive instruments and improved imaging techniques, will eventually overcome this problem. Until then, some excavation is necessary in order to ascertain the presence or absence of horizontally extensive deposits.

As geophysicists and archaeologists learn to work together and exchange information more effectively, it will be possible to reduce the amount of excavation needed to assess the NRHP eligibility of a site. Geophysical surveys allow excavations to be targeted on those anomalies judged most likely to represent cultural features. In many cases, this targeting will allow intact cultural deposits to be identified with less excavation than typifies most traditional assessments. At sites where geophysical surveys identify no anomalies suggestive of cultural deposits, it will also be reasonable to do less excavation than characterizes traditional assessments. The use of geophysics will reduce the risk of failing to document small, widely spaced features. The judicious use of geophysical techniques in site assessment should therefore obviate the practice of recommending as eligible for the National Register sites where only marginally intact and/or significant deposits have been documented, but where it is thought that "better" deposits may be present.

Comparison of Geophysical and Traditional Assessments at Ft. Riley

The present monograph reports on a comparison of the costs and benefits associated with the use of traditional and geophysical site assessments strategies. This was a controlled comparison in that the two strategies were employed at the same four sites at Ft. Riley. An abbreviated resistivity survey was conducted at an optional fifth site, 14RY193. This effort involved the resistivity fieldwork and preparation of a draft map, but this site was not included in the Geoscan report. The cost benefit study did not include any archaeological work at 14RY193, although a traditional NRHP assessment was conducted there later as a separate project (Halpin 1997). In the following discussion, it is necessary to estimate costs of the geophysical investigations in two ways: 1) including 14RY193, and 2) omitting the site. Including 14RY193 results in a significantly smaller mean cost per site for the geophysical assessments, whereas deleting the site increases the mean cost.

Archaeological investigations were conducted by the University of Illinois Public Service Archaeology Program (PSAP) (Kreisa and Walz 1997). The geophysical investigations were conducted by Geoscan Research (USA) (Somers 1997). During the traditional site assessment, PSAP was not provided with information about the results of the geophysical survey. This represented an effort to keep the two site assessments as independent as possible. The results of the geophysical and traditional investigations at each site have been summarized in some detail in the preceding chapter. It is useful here to focus on the costs and benefits, strengths and weaknesses of each approach.

Cost

The estimated cost per site of the traditional assessments ranged from \$7,318.37 to \$21,318.70, with a mean of \$12,957.43. These figures pertain to the four sites included in the cost benefit study, and do not include 14RY193. The costs per site are estimates in that they are based on the number of hours devoted to each site as reported by PSAP (Kreisa and Walz 1997:137). The estimated costs per site do not include the excavation, artifact analysis, or that portion of the report preparation associated with the anomaly tests.

The estimated costs of the geophysical site assessments ranged from \$2,782.61 to \$11,913.43, with a mean of \$6,327.06. This mean is based on five sites, i.e., including 14RY193. In addition to Geoscan's geophysical surveys, these figures include excavation, analysis, and (pro-rated) report costs associated with PSAP's ground truthing excavations. If one chooses to omit the abbreviated geophysical survey at 14RY193, the mean cost for the other 4 sites increases to \$7,908.83.

It is apparent that the cost per site of the geophysical assessment was approximately 50 to 60% that of the traditional assessments. It is, however, important to keep several factors in mind when evaluating the apparent cost advantages of the geophysical assessments. First, no ground truthing is included in the cost estimates for two of the sites. At 14RY5155, the geophysical survey identified no anomalies warranting ground truthing. The abbreviated resistivity survey at 14RY193

(the "extra" site) revealed several anomalies interpretable as architectural remains. A traditional assessment was conducted there as part of a separately funded project (Halpin 1997), but the excavation units were not intentionally positioned so as to investigate geophysical anomalies.

A second factor contributing to the relatively low costs associated with the geophysical site assessments is the limited amount of ground truthing excavation conducted at the other three sites (14RY3183, 14RY3193, and 14GE3108). This project's SOW called for the excavation of 60 shovel tests to ground truth anomalies, an average of 15 per site. The abundance of anomalies warranting ground truthing excavations at the Army City site reduced the amount of excavation that could be done at the other two sites where anomalies were identified.

Finally, (as has been discussed above), ground truthing of geophysical anomalies alone does not represent a fully adequate site assessment strategy. To adequately assess National Register eligibility for most sites, it would be necessary to excavate shovel (or posthole) tests at regular intervals in order to document the presence/absence of horizontally extensive cultural strata.

Additional excavations would have been necessary in order to make the geophysical and ground truthing investigations conducted at 14RY3183, 14RY3193, and 14GE3108 (and the geophysical surveys at 14RY5155 and 14RY193) adequate site assessments. Additional shovel tests could be excavated without sacrificing the full cost advantages of the geophysical assessment strategy. It is a useful exercise to demonstrate this using data from the present study. Table 4 indicates that the estimated cost of the 60 shovel tests used in this study to ground truth anomalies was $7,635.29, or $127.25 per test; (recall that this seemingly high figure includes costs associated with artifact analysis and report preparation). The mean cost per site of the geophysical assessments ($6,327.06) is $6,630.37 less than the mean cost per site of the traditional assessments ($12,957.43). The difference between the mean costs is $5,048.60 if one omits 14RY193. If one used the $5,048.60 to $6,630.37 difference for additional ground truthing, one could excavate an additional 40 to 52 shovel tests per site. Added to the average of 15 shovel tests called for by the SOW, the geophysical assessment would then entail the excavation of 52 to 67 shovel tests per site. Assuming that these shovel tests measured .45 by .45 m, 11.14 to 13.57 m^2 would be excavated at each site.

One finding of this study is that shovel tests do not represent the ideal approach to ground truthing for all anomalies. The work at the Army City and Station Agent sites suggested that long, narrow trenches would be better than shovel tests for the investigation of large anomalies, such as those likely to be associated with architectural features. Shovel tests are, however, more economical per unit volume than test units or trenches. This economy probably reflects the fact that shovel tests do not typically involve as much troweling of floors and walls, preparation of scaled maps and photographs, etc. Thus, a ground truthing strategy that involves a mixture of test units and shovel tests will be more expensive than one that uses only shovel tests to excavate the same volume of soil.

On balance, estimated costs of the geophysical site assessment strategy are competitive with the average cost of traditional assessments conducted in Kansas since 1990. To the extent that

traditional assessments currently cost more than $8,000, the geophysical strategy is more competitive.

Reliability

In the context of assessing an archaeological site's eligibility for the National Register, reliability can be thought of as the probability of identifying intact cultural deposits when such deposits are present at a site. The failure to identify cultural deposits obviously does not make an assessment unreliable if no such deposits are present there. The difficulty in using this concept of reliability, however, is that it implies an omniscient knowledge about the features actually present at a site. If no cultural deposits are identified, one does not know if they are truly absent or if the methods (including the sampling strategy) used to search for them were inadequate. While this issue does prevent one from quantifying the reliability of a particular strategy, it does not prevent one from comparing two strategies in terms of reliability. In other words, if one strategy results in the identification of 10 cultural features and the other strategy only identifies 5 of those, the latter is clearly less reliable (as a feature finding method) than the former.

At site 14RY5155, neither assessment strategy produced any indication of features. The traditional assessment documented a very low density of artifacts, suggesting that the site is the result of a series of ephemeral occupations that did not involve the creation of substantial pits, hearths, or architectural remains.

The traditional and geophysical investigations at the ForThree site (14RY3183) both failed to identify any discrete features. The traditional investigations did, however, document the presence of intact, horizontally extensive cultural deposits (midden) in several of the test units. Traditional investigations conducted at the ForThree site prior to the PSAP fieldwork (Richardson 1997) identified a concentration of daub interpreted as the remains of a prehistoric domestic structure, and subsequent traditional investigations (Richardson et al. 1997) identified a concentration of rock slabs interpreted as a hearth. The magnetic and resistivity surveys both failed to detect these features. Reasons for this failure include the presence of historic and/or recent metallic debris and surficial soil disturbances associated with timber clearing and installation of a gravel access road that passed directly through the prehistoric structure/hearth complex (Richardson et al. 1997). On balance, the traditional site assessment strategy was more reliable than the geophysical approach at the ForThree site.

At Army City (14RY3193), the traditional assessment revealed no midden strata or subsurface features. In contrast, the magnetic and resistivity surveys identified a large number of anomalies, many of which were interpreted (prior to ground truthing) as architectural features. Fifty-one such anomalies were designated as candidates for ground truthing, and many more could have been similarly designated. Forty-three of the anomalies were investigated using shovel tests. Of these, one definite feature (a concrete slab 65 cm bs) and 17 possible features were identified. The latter were characterized by slightly disturbed (mottled) soil profiles and, in many cases, modest

concentrations of cultural debris. It was not possible to determine the type of features represented by these disturbed areas. On balance, however, the geophysical site assessment strategy was substantially more reliable than the traditional approach at Army City.

At the Station Agent site (14GE3108), the traditional assessment strategy was very successful at identifying features. Two features were identified in shovel tests and three features and one area of midden were documented in the four test units. Factors that account for this success in identifying features include the intensity of historic occupation at this relatively small site, and the presence of surface indications of subsurface features. Resistivity and magnetic surveys at Station Agent revealed a number of anomalies, 22 of which were designated as candidates for ground truthing. Ten shovel tests were excavated to investigate 7 of the anomalies. Three suspected structural features were each investigated using a pair of shovel tests, one located within the structure and the other located outside. Two of the paired shovel tests identified structural features. In the third pair, the shovel test located within the suspected structure recovered several pieces of concrete but no in-situ structural remains. The remaining anomaly tests were targeted on magnetic anomalies. Two of the magnetic anomalies were interpreted as concentrations of metal objects, one as a pipe/drain/trench, and one as a road/path/or dozer tailings. None of the shovel tests targeted on magnetic anomalies encountered features. In all probability, the geophysical strategy could have resulted in the discovery of additional features if the ground truthing shovel tests had been focused on resistivity anomalies, or if a larger number of anomaly tests had been excavated. On balance, however, the traditional assessment was a little more reliable than the geophysical strategy at 14GE3108.

The Thomas R. Hair site (14RY193) was not officially included in the cost benefit study. As a professional courtesy, an abbreviated resistivity survey was conducted there after the work required by the cost benefit project's SOW had been completed. A resistivity map of the site was produced but no list of anomalies warranting ground truthing was prepared. A traditional site assessment was later conducted at the Hair site as part of a separate project (Halpin 1997), but no effort was made to ground truth the resistivity anomalies. Thus, it is appropriate to make only very general observations about the success with which the traditional and geophysical assessment strategies identified features.

A walk-over inspection of the Hair site resulted in the identification of 10 features (Halpin 1997). The subsequent excavation of 113 posthole tests and four 1 x 2 m test units documented a coursed limestone foundation associated with Feature 7 (a house). All of the features documented by the traditional assessment had some surface manifestations. The resistivity survey covered only a portion of the site area included in the traditional assessment. A number of the features documented by the traditional assessment are readily visible in the resistivity map, but several of the features are not clearly discernable. The resistivity map also includes several high resistivity anomalies that do not correspond to documented features. Because the resistivity data from the Hair site were not fully processed and interpreted, and subsequent excavations were not designed to ground truth the geophysical anomalies, it is not appropriate to state that one site assessment strategy was more reliable than the other.

Conclusions

This monograph has reported the findings of a controlled comparison of the costs and benefits associated with the traditional site assessment strategy vs. an alternative strategy based on use of geophysical surveys and targeted ground truthing. Both strategies were used at the same four sites at Ft. Riley, Kansas. Additional data from a fifth site that was included in the geophysical survey but not in the ground truthing component of the study has also been discussed.

The average cost per site of the geophysical assessment ($6,327.06, or $7,908.83 if one omits 14RY193) was substantially less than the average of the traditional assessments ($12,957.43). Similarly, the geophysical strategy was substantially less expensive at three of the four sites (see Tables 2 and 4). At Army City, the geophysical assessment ($11,913.43) was significantly more expensive than the traditional assessment ($7318.37). This difference reflects the excavation of 43 shovel tests to ground truth anomalies at that site.

The geophysical assessments included an average of only 15 shovel tests per site, and this would probably not be adequate for many sites; (in Kansas, NRHP assessments typically include the hand excavation of test units exposing ca. 6 m^2 and, in many cases, ca. 20 shovel tests). The number of shovel tests could be substantially increased, however, without entirely negating the cost advantages of the geophysical strategy.

The reliability of a site assessment strategy has been defined here as the success with which it detects features when features are present. This definition clearly has some limitations, but it does allow one to compare the reliability of two strategies used at the same site. It was found here that the traditional strategy was clearly more reliable at the ForThree site, where a horizontally extensive midden stratum and a structure and rock hearth complex were encountered in test units but were not identified by the geophysical surveys. At the Station Agent site, the traditional assessment strategy resulted in the identification of 5 subsurface features and a midden deposit. In comparison, ground truthing of anomalies at Station Agent resulted in the documentation of 2 features. Strictly speaking, the traditional approach was more reliable at the Station Agent site because it resulted in the identification of more features than did the geophysical approach. It is important to note, however, that additional features were discernable on the geophysical maps but were not ground truthed. A small amount of additional ground truthing at the Station Agent site would almost certainly have resulted in the documentation of additional features. At Army City, the traditional investigations failed to detect any midden or features whereas the geophysical assessment identified a considerable number of features or loci of cultural disturbance.

On balance, it appears that a site assessment strategy based on geophysical survey and targeted ground truthing excavation has the potential to be more cost effective than the traditional approach, at least in some situations. This study has also demonstrated that the geophysical approach to site assessment can be more reliable than the traditional approach, at least at some sites. One

should also consider the implications of these findings from the other perspective. In some situations, the traditional approach to site assessment will continue to be more cost effective and more reliable than the geophysical approach. Thus, an important objective for future research is to identify the kinds of situations where geophysics can make a contribution to site assessment, as well as those situations where it is advisable to continue using the traditional assessment strategy.

Recommendations for Future Work

In conclusion, it is useful to emphasize several key points concerning the use of geophysics in assessing the National Register eligibility status of archaeological sites:

Geophysical techniques vary greatly in terms of their potential cost effectiveness and reliability. Factors that affect this variability include vegetation, soil and bedrock characteristics, moisture, nature of recent soil disturbances (plowing, vehicle traffic, bulldozing), and nature of the archaeological record. To realize the potential advantages of geophysics, it is essential that the appropriate technique(s) be identified and used. Similarly, it is important to recognize those situations where use of the traditional site assessment strategy will yield the most cost effectiveness and reliability.

Experience at Ft. Riley indicates that geophysics contributes less to a site assessment in situations where historic architectural remains are visible on the surface. Surface indications of architectural remains allow traditional excavation techniques such as systematic posthole tests to be used in a cost effective manner. Geophysics makes the greatest contribution in situations where it can provide detailed information about intra-site spatial patterning that would not otherwise be available.

Geophysics will make a greater contribution to site assessments conducted at relatively undisturbed sites than at those that have been heavily impacted by vehicular traffic, bulldozing, etc. (e.g., ForThree site). This observation is particularly true regarding prehistoric sites, where one expects to find (under the best of circumstances) very subtle contrasts between cultural deposits and the surrounding matrix.

Geophysics can improve the cost effectiveness and reliability of NRHP assessments of large sites (e.g., Army City) where use of traditional techniques will expose only a miniscule portion of the total site area.

Ground truthing techniques should be chosen with a consideration of both cost and reliability issues. Great care must be taken to minimize the possibility that shovel tests will be mislocated slightly, thereby failing to intersect small anomalies. At Ft. Riley it was found that shovel tests did not represent an optimal approach to ground truthing some anomalies. In order to recognize a feature, it is generally necessary to observe a contrast between it and the surrounding soils. In many cases, a shovel test may be located entirely within an anomaly, making it difficult to determine if the anomaly represents a cultural feature, and if so, to determine feature form, dimensions, integrity, etc.

It is advisable to conduct ground truthing excavations in several stages, beginning with the use of Oakfield cores, posthole, or shovel tests to locate anomalies. The most promising anomalies can then be more thoroughly investigated using narrow trenches or small test units.

At many (perhaps most) sites, it will be necessary to excavate shovel tests at regular intervals so as to ascertain the presence/absence of horizontally extensive deposits. In order to secure data on soil stratigraphy and artifact distributions, it will be necessary to screen each shovel test, and to prepare profile maps or descriptions for a representative sample of the tests.

In some situations, it may be cost effective to use geophysics to screen a group of sites in order to identify those that most warrant a formal NRHP eligibility assessment. For example, Ft. Riley includes a large number of historic sites that have already sustained adverse impacts from building demolition and military training activities. Based on surface indications, these sites appear to have little potential to be eligible for nomination to the National Register. For some of these sites, however, it is desirable to confirm the absence of intact subsurface deposits. Geophysics can be used to search for anomalies suggestive of intact features. Assuming that no promising anomalies are detected, it may be appropriate to do little or no excavation at these sites. But if promising anomalies are identified, the investigation can be expanded into a formal assessment of National Register eligibility. Such uses of geophysics should be made in the context of a comprehensive management plan and following consultation with the SHPO.

The success of a geophysical site assessment requires effective communication between an archaeologist familiar with the local soils and feature types, and a geophysicist who has a clear understanding of the ephemeral nature of the archaeological record.

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GLOSSARY

Anomaly: A locus characterized by one or more geophysical data values that differ significantly from those of surrounding loci. Anomalies are frequently manifestations of subsurface cultural features or natural disturbances.

Archaeological Feature: An object or discrete group of objects that is visually distinct from surrounding materials, and that is the result of human activity. Features are often constructed facilities, such as storage pits or hearths. Features may also be the unintentional result of human activities, such as a burned area on a living surface, or a concentration of refuse. Features are of particular interest to archaeologists because they often relate to specific time intervals and/or activities, and are thus informative about the chronology and nature of a site's occupation.

Ground Penetrating Radar (GPR): A geophysical method in which an electromagnetic signal is sent into the soil via a transmitting antennae. As the electromagnetic waves contact materials of varying electrical impedance, they are reflected or attenuated. Waves reflected back to a receiving antennae on the surface are compared with the transmitted signal (Heimmer and De Vore 1995:41).

Ground Truthing: The investigation of the subsurface origin of a geophysical anomaly by means of hand excavation. For example, a geophysical anomaly thought to correspond to a prehistoric hearth might be ground-truthed by excavating a shovel probe or small test unit.

Integrity: The ability of a historic property to convey its significance (USDI 1995:44-49). The National Register eligibility criteria recognize seven aspects of integrity, including location, design, setting, materials, workmanship, feeling, and association.

Magnetic Survey: A survey conducted to measure the magnetic field at a site, with the objective of identifying magnetic anomalies that may correspond to subsurface cultural features or artifacts.

Midden: A horizontally extensive deposit comprised in part of culturally deposited materials. The term is generally used in reference to deposits characterized by a relatively high density of artifacts and organic remains resulting from human activity.

National Register of Historic Places: A listing of historic properties, including buildings, sites, districts, structures, and objects that have been determined to be significant in American history, archaeology, engineering, architecture, and culture. Significance (see below) is assessed using four criteria (USDI 1995:1-2). To be eligible for the National Register, properties must also possess the quality of integrity (see above). Properties that have achieved significance in the last 50 years are generally not eligible for the National Register.

Resistivity Survey: A survey conducted to measure the resistivity (resistance to the passage of an

electrical current) across a site, with the objective of identifying anomalies that may correspond to subsurface cultural features.

Significance: "The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and...that are associated with events that have made a significant contribution to the broad patterns of our history; or...that are associated with the lives of persons significant in our past; or...that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or...that have yielded, or may be likely to yield, information important in prehistory or history." (USDI 1995:2).

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